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ROADSIDE DEVICE

Abstract

A roadside device including an imaging unit, a communication unit, a notification unit, and a control unit, wherein when a pedestrian near a road is detected from a video from the imaging unit, the control unit receives vehicle information including relative position information between a first vehicle that is an autonomous driving vehicle approaching the roadside device and a second vehicle around the first vehicle from an information processing device via the communication unit, and notifies the pedestrian of notification information including the relative position information by the notification unit.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to Japanese Patent Application No. 2024-018922 filed on Feb. 9, 2024, incorporated herein by reference in its entirety.

BACKGROUND

1. Technical Field

[0002] The present disclosure relates to roadside devices.

2. Description of Related Art

[0003] Conventionally, there has been known a technique related to roadside devices that notify people to be notified such as pedestrians and drivers and assistant drivers of vehicles of the presence of a vehicle or a pedestrian. For example, Japanese Unexamined Patent Application Publication No. 2023-50629 (JP 2023-50629 A) discloses a notification system. This notification system notifies pedestrians or vehicles other than an autonomous vehicle that is going to pass through a predetermined traffic area of whether the pedestrians or the vehicles can proceed, or alerts the pedestrians or the vehicles, according to the behavior of the autonomous vehicle.

SUMMARY

[0004] The operation of an autonomous vehicle cannot be predicted from the behavior (gesture, eye contact, etc.) of its driver or assistant driver. It is therefore desirable from the safety point of view to notify pedestrians of the presence of an autonomous vehicle. However, it is sometimes difficult for pedestrians to determine whether the vehicle is being autonomously driven by merely looking at the vehicle from the outside. Therefore, when a plurality of vehicles including an autonomous vehicle approaches a pedestrian, the pedestrian may not be able to determine which vehicle is an autonomous vehicle if the pedestrian is only notified that an autonomous vehicle is approaching.

[0005] In view of such circumstances, an object of the present disclosure is to improve the technique related to roadside devices.

[0006] A roadside device according to an embodiment of the present disclosure includes: an imaging unit; a communication unit; a notification unit; and a control unit. The control unit is configured to when a pedestrian near a road is detected from a video from the imaging unit, receive vehicle information from an information processing device via the communication unit, the vehicle information including relative position information between a first vehicle that is an autonomous vehicle approaching the roadside device and a second vehicle located around the first vehicle, and cause the notification unit to notify the pedestrian of notification information including the relative position information.

[0007] According to the embodiment of the present disclosure, the technique related to roadside devices is improved.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] Features, advantages, and technical and industrial significance of exemplary embodiments of the disclosure will be described below with reference to the accompanying drawings, in which like signs denote like elements, and wherein:

[0009] FIG. **1** is a block diagram illustrating a schematic configuration of a system according to an

embodiment of the present disclosure;
[0010] FIG. **2** is a block diagram illustrating a schematic configuration of a first vehicle that is an autonomous vehicle;
[0011] FIG. **3** is a block diagram illustrating a schematic configuration of a roadside device;
[0012] FIG. **4** is a block diagram illustrating a schematic configuration of an information processing device;
[0013] FIG. **5** is a flow chart illustrating the operation of the roadside device; and
[0014] FIG. **6** is an example of an image displayed on a display of a roadside device.

DETAILED DESCRIPTION OF EMBODIMENTS

[0015] Hereinafter, an embodiment of the present disclosure will be described.

Outline of Embodiment

[0016] The outline of a system **1** according to an embodiment of the present disclosure will be described with reference to FIG. **1**. The system **1** includes a first vehicle **10**, a roadside device **20**, and an information processing device **30**. The first vehicle **10**, the roadside device **20**, and the information processing device **30** are communicably connected to a network **40** including, for example, the Internet and a mobile communication network.
[0017] The first vehicle **10** is a connected car having a communication function with the network **40**. The driving of the vehicle **10** is automated at any level. The level of automation may be, for example, any of level 1 to level 5 in the level division of society of automotive engineers (SAE). The first vehicle **10** may be driven by a driver. The first vehicle **10** is, for example, a vehicle such as a battery electric vehicle (BEV), a hybrid electric vehicle (HEV), a plug-in hybrid electric vehicle (PHEV), or a fuel cell electric vehicle (FCEV), but is not limited thereto, and may be any vehicle capable of being ridden by a human. The system **1** may comprise one or more first vehicles **10**.
[0018] The first vehicle **10** includes a camera for detecting a second vehicle **50** around the first vehicle **10**. In the present embodiment, since the second vehicle **50** does not have a communication function with the network **40**, the first vehicle **10** needs to detect the second vehicle **50** in order to acquire the information on the second vehicle **50**.
[0019] The roadside device **20** is installed at a position where the pedestrian **60** can be detected from the video from the mounted camera, for example, near the boundary between the road and the sidewalk. The roadside device **20** includes a notification unit **23** for notifying the pedestrian **60** of vehicle information. The notification unit **23** includes, for example, a display and/or a speaker.
[0020] The information processing device **30** is one or more computers such as a server device. In the present embodiment, communication between the first vehicle **10** and the roadside device **20** is performed via the information processing device **30**. For example, the information of the first vehicle **10** and the information of the second vehicle **50** detected by the first vehicle **10** are transmitted to the roadside device **20** via the information processing device **30**. The information processing device **30** may communicate with the first vehicle **10** and continuously receive information of the first vehicle **10**.
[0021] First, the outline of the present embodiment will be described, and the details will be described later. The roadside device **20** includes an imaging unit **21**, a communication unit **22**, a notification unit **23**, and a control unit **25**. The roadside device **20** receives vehicle information from the information processing device **30** via the communication unit **22** when the pedestrian **60** near the road is detected from the video from the imaging unit **21**. The vehicle information includes relative position information of the first vehicle **10**, which is an autonomous vehicle approaching the roadside device **20**, and the second vehicle **50** around the first vehicle **10**. The roadside device **20** notifies the pedestrian **60** of the notification information including the relative position information by the notification unit **23**.
[0022] According to the present embodiment, the pedestrian **60** can grasp the relative position between the autonomous vehicle and another vehicle around the autonomous vehicle. Accordingly,

the pedestrian **60** can identify the autonomous vehicle from among the plurality of vehicles. Therefore, the safety of the pedestrian **60** is improved.

[0023] Further, according to the present embodiment, the roadside device **20** can notify the pedestrian **60** of the presence of the vehicle located at the blind spot of the roadside device **20** generated by the plurality of vehicles. For example, when an autonomous vehicle is located behind a large vehicle such as a truck or in front of a small vehicle such as a motorcycle, the roadside device **20** can notify the pedestrian **60** of information on the autonomous vehicle and information on the vehicle around the autonomous vehicle. Accordingly, the pedestrian **60** can grasp the vehicle located at the blind spot, and thus the safety of the pedestrian **60** is improved.

[0024] As described above, the present embodiment improves the technology related to the roadside device **20**.

[0025] Next, each configuration of the system I will be described in detail.

[0026] As illustrated in FIG. **2**, the first vehicle **10** includes a communication unit **11**, a detection unit **12**, a storage unit **13**, and a control unit **14**.

[0027] The communication unit **11** includes one or more communication interfaces connected to the network **40**. This communication interface corresponds to a mobile communication standard such as 4th generation (4G) or 5th generation (5G), for example, but is not limited thereto. The communication unit **11** may include an inter-vehicle interface for communicating with the second vehicle **50** around the first vehicle **10**.

[0028] The detection unit **12** includes one or more cameras capable of detecting one or more second vehicles **50** around the first vehicle **10**. The detection unit **12** may include, for example, two or more cameras arranged at positions capable of capturing an image of the periphery of the first vehicle **10**, or an omnidirectional camera capable of capturing an image of the periphery of the first vehicle **10**. The detection unit **12** may further include a device for measuring the inter-vehicle distance, for example, a millimeter-wave radar or a LiDAR. The detection unit **12** may detect the second vehicle **50** by inter-vehicle communication using the inter-vehicle interface of the communication unit **11**.

[0029] The storage unit **13** includes one or more memories. The memories are, for example, a semiconductor memory, a magnetic memory, or an optical memory, but are not limited to these memories. Each memory included in the storage unit **13** may function as, for example, a main storage device, an auxiliary storage device, or a cache memory. The storage unit **13** stores arbitrary information used for the operation of the first vehicle **10**. For example, the storage unit **13** may store a system program, an application program, embedded software, and information of the first vehicle **10**. The information stored in the storage unit **13** may be updatable by, for example, information received from the network **40** via the communication unit **11**.

[0030] The control unit **14** includes one or more processors, one or more programmable circuits, one or more dedicated circuits, or a combination thereof. The processors are, for example, a general-purpose processor such as a central processing unit (CPU) or a graphics processing unit (GPU), or a dedicated processor specialized for a specific process, but are not limited to these processors. The programmable circuits are, for example, a field-programmable gate array (FPGA), but are not limited to the circuit. The dedicated circuits are, for example, an application specific integrated circuit (ASIC), but are not limited to the circuit. The control unit **14** controls the overall operation of the first vehicle **10**.

Configuration of the Roadside Device **20**

[0031] As illustrated in FIG. **3**, the roadside device **20** includes an imaging unit **21**, a communication unit **22**, a notification unit **23**, a storage unit **24**, and a control unit **25**. The roadside device **20** is installed at a position where the pedestrian **60** can be detected from the video from the mounted imaging unit **21**, for example, near the boundary between the road and the sidewalk. The roadside device **20** may be installed near a crosswalk, near an intersection, or the like. The roadside device **20** may or may not be fixed to a road or sidewalk.

[0032] The imaging unit **21** includes one or more cameras for photographing the pedestrian **60**. The camera may capture an image of the first vehicle **10** or the second vehicle **50**. For example, the imaging unit **21** may include two 90-degree cameras, two 180-degree cameras, or one 360-degree camera.
[0033] The communication unit **22** includes one or more communication interfaces connected to the network **40**. The communication interfaces correspond to, but are not limited to, a mobile communication standard such as 4th generation (4G) or 5th generation (5G), a wired LAN standard, or a radio LAN standard.
[0034] The notification unit **23** includes one or more notification devices for notifying the pedestrian **60** near the roadside device **20** of information. The notification device may include a display and/or a speaker. The notification unit **23** may further include a notification device for directly notifying the driver or assistant driver of the first vehicle **10** of the information of the pedestrian **60**, for example, an electric bulletin board or a blinking light.
[0035] The storage unit **24** includes one or more memories. Each memory included in the storage unit **24** may function as, for example, a main storage device, an auxiliary storage device, or a cache memory. The storage unit **24** stores arbitrary information used for the operation of the roadside device **20**. For example, the storage unit **24** may store a system program, an application program, embedded software, and the like. The information stored in the storage unit **24** may be updatable by, for example, information acquired from the network **40** via the communication unit **22**.
[0036] The control unit **25** includes one or more processors, one or more programmable circuits, one or more dedicated circuits, or a combination of these. The control unit **25** controls the operation of the roadside device **20**.

Configuration of the Information Processing Device **30**

[0037] As illustrated in FIG. **4**, the information processing device **30** includes a storage unit **31**, a communication unit **32**, and a control unit **33**.
[0038] The storage unit **31** includes one or more memories. Each of the memories included in the storage unit **31** may function as a main storage device, auxiliary storage device, or cache memory, for example. The storage unit **31** stores arbitrary information used for the operation of the information processing device **30**. For example, the storage unit **31** may store a system program, an application program, embedded software, a position of the roadside device **20**, map information, and the like. The information stored in the storage unit **31** may be updatable by, for example, information received from the network **40** via the communication unit **32**.
[0039] The communication unit **32** includes one or more communication interfaces connected to the network **40**. This communication interface corresponds to a mobile communication standard such as 4th generation (4G) or 5th generation (5G), for example, but is not limited thereto. In the present embodiment, the information processing device **30** communicates with the vehicle **10** and the roadside device **20** via the communication unit **32** and the network **40**.
[0040] The control unit **33** includes one or more processors, one or more programmable circuits, one or more dedicated circuits, or a combination of these. The control unit **33** controls the overall operation of the information processing device **30**.

Operation Flow of the Roadside Device **20**

[0041] The operation of the roadside device **20** according to the present embodiment will be described with reference to FIG. **5**.
[0042] S**100**: The control unit **25** of the roadside device **20** detects the pedestrian **60** near the road from the video from the imaging unit **21**.
[0043] The control unit **25** detects the pedestrian **60** in the video by an arbitrary object recognition process. The control unit **25** may specify that the pedestrian **60** is moving and the moving direction of the pedestrian **60** from the change in the position of the pedestrian **60** in the video. The control unit **25** may identify the pedestrian **60** moving toward the road as a “pedestrian near the road”.
[0044] S**101**: The control unit **25** receives, from the information processing device **30** via the

communication unit **22**, vehicle information including relative position information between the first vehicle **10** that is an autonomous vehicle approaching the roadside device **20** and the second vehicle **50** located around the first vehicle **10**.

[0045] Specifically, first, the control unit **25** of the roadside device **20** transmits a request for acquiring vehicle information to the information processing device **30** via the communication unit **22**. The control unit **33** of the information processing device **30** transmits the acquisition request to the first vehicle **10** via the communication unit **32**. The control unit **14** of the first vehicle **10** detects the second vehicle **50** by the detection unit **12** in response to the acquisition request. In the present embodiment, since the second vehicle **50** does not have a communication function with the network **40**, it is necessary to detect the second vehicle **50** by the first vehicle **10**. The control unit **14** of the first vehicle **10** may detect two or more second vehicles **50** by the detection unit **12**. The second vehicle **50** may travel or stop. Furthermore, the control unit **14** transmits the information of the first vehicle **10** and the detected information of the second vehicle **50** to the information processing device **30** via the communication unit **11**. The control unit **33** calculates relative position information based on information (for example, positions) of the first vehicle **10** and the second vehicle **50**. The control unit **33** further transmits vehicle information including the relative position information to the roadside device **20** via the communication unit **32**.

[0046] The relative position information may include any information regarding the relative positional relationship between the first vehicle **10** and the second vehicle **50**. For example, the relative position information may include information indicating the number of the first vehicles and the second vehicles, information identifying that the first vehicle **10** is an autonomous vehicle, and information indicating the position of the first vehicle **10** with respect to the second vehicle **50** when viewed from the roadside device **20**. The relative position information may include information indicating a positional relationship (front-rear, left-right diagonal direction) or a distance between the first vehicle **10** and the second vehicle **50**. For example, the relative position information may include information indicating that the autonomous vehicle (first vehicle **10**) is traveling behind the truck or the like (second vehicle **50**). Alternatively, the relative position information may include information indicating that the autonomous vehicle (the first vehicle **10**) approaches from the side of the vehicle train (the plurality of second vehicles **50**) that is stopped. The relative position information is not limited to the above-described example, and may include information such as a size, a type, a position on a road, a distance from the roadside device **20**, and a speed (for example, a legal speed or an excess of a speed limit), of the first vehicle **10** and the second vehicle **50**. The relative position information may include information indicating that the first vehicle **10** or the second vehicle **50** is about to turn right and left, is about to be suddenly braked, is about to exit the congested train, or is about to overtake the vehicle. The vehicle information is not limited to the relative position information, and may include any information regarding the first vehicle **10** and the second vehicle **50**.

[0047] The relative position information may include an image displayed on the display of the roadside device **20** and/or a message output by a speaker of the roadside device **20**. FIG. **6** is an example of an image displayed on a display. The image shows the first vehicle **10**, the roadside device **20**, the second vehicle **50**, and the pedestrian **60** on a schematic map. The roadside device **20** is disposed near the crosswalk. The pedestrian **60** is located near the roadside device **20**. The first vehicle **10** and the second vehicle **50** travel on the roadside and approach the roadside device **20** and the pedestrian **60**. The image indicates that the first vehicle is traveling behind the second vehicle **50**. The images are textually displaying information identifying that the first vehicle **10** is an autonomous vehicle, a distance between the roadside device **20** and the second vehicle (“50 m” in FIG. **6**), and a distance between the second vehicle and the first vehicle **10** (“20 m” in FIG. **6**). The image may use color coding, arrows, flashing, etc. to emphasize that the first vehicle is an autonomous vehicle. By viewing the image, the pedestrian **60** can understand the number of the first vehicle **10** and the second vehicle **50**, the order of the first vehicle **10** with respect to the

second vehicle **50** when viewed from the roadside device **20**, and the positional relationship between the first vehicle **10** and the second vehicle **50**. The messages output by the speaker are messages such as “Two vehicles are approaching from the right. The second vehicle from the head is an autonomous vehicle. ”, “The vehicle is approaching from **50** meters to the right. The autonomous vehicle comes closer to 25 meters behind the head vehicle.”

[0048] S**102**: The control unit **25** notifies the pedestrian **60** of notification information including the relative position information by the notification unit **23**.

[0049] The relative position information is notified to the pedestrian **60** by, for example, an image displayed on the display of the roadside device **20** or a sound output by a speaker of the roadside device **20**. The notification information may further include vehicle information other than the relative position information, crossing availability information indicating whether or not the pedestrian **60** can cross the road, or attention calling information urging the pedestrian **60** to pay attention to the left and right.

[0050] As described above, the roadside device **20** according to the present embodiment receives the vehicle information from the information processing device **30** via the communication unit **22** when the pedestrian **60** near the road is detected from the video from the imaging unit **21**. The vehicle information includes relative position information of the first vehicle **10**, which is an autonomous vehicle approaching the roadside device **20**, and the second vehicle **50** around the first vehicle **10**. The roadside device **20** notifies the pedestrian **60** of the notification information including the relative position information by the notification unit **23**.

[0051] With this configuration, the pedestrian **60** can grasp the relative position between the autonomous vehicle approaching the roadside device **20** and another vehicle surrounding the autonomous vehicle. Accordingly, the pedestrian **60** can identify the autonomous vehicle from among the plurality of vehicles. Therefore, the safety of the pedestrian **60** is improved.

[0052] According to this configuration, the roadside device **20** can notify the pedestrian **60** of the presence of the vehicle located at the blind spot of the roadside device **20** generated by the plurality of vehicles. For example, even when an autonomous vehicle is located behind a large vehicle such as a truck or in front of a small vehicle such as a motorcycle, the roadside device **20** can notify the pedestrian **60** of information on the autonomous vehicle and information on the vehicle detected by the autonomous vehicle. Accordingly, the pedestrian **60** can grasp the vehicle located at the blind spot, and thus the safety of the pedestrian **60** is improved.

[0053] Although the present disclosure has been described with reference to the drawings and examples, it should be noted that various changes and modifications may be made by those skilled in the art based on the present disclosure. It should therefore be noted that these variations and modifications are within the scope of the present disclosure. For example, the functions included in the configurations, steps, etc. can be rearranged so as not to be logically inconsistent, and a plurality of configurations, steps, etc. can be combined into one or divided.

[0054] The roadside device **20** may receive the vehicle information from the first vehicle **10** without passing through the information processing device **30**. In a case where the second vehicle **50** has a communication function with the network **40**, the roadside device **20** may receive the information of the first vehicle **10** and the second vehicle **50** from the first vehicle **10** and the second vehicle **50** without passing through or via the information processing device **30**, and acquire the vehicle information.

[0055] The roadside device **20** may send the pedestrian information on the pedestrian **60** detected from the video from the imaging unit **21** to the first vehicle **10** or a mobile terminal carried by the driver or assistant driver of the first vehicle **10** via the information processing device **30**. Thus, the driver or assistant driver of the first vehicle **10** can grasp the behavior of the pedestrian **60** based on the received pedestrian information. The pedestrian information may include information indicating the presence, crossing situation, or pop-out of the pedestrian **60**. The mobile terminal may be, for example, a smartphone, a tablet, or a laptop computer. The information processing

device **30** may further transmit the stop information recommending the stopping of the traveling to the first vehicle **10** or the mobile terminal carried by the driver or assistant driver of the first vehicle **10**. The information processing device **30** may also notify vehicle information. Thus, the driver or assistant driver of the first vehicle **10** can recognize the behavior of the second vehicle **50**, for example, the sudden braking applied by the driver of the second vehicle **50** who views the pedestrian **60**.

[0056] The roadside device **20** may directly notify the driver or assistant driver of the first vehicle **10** of the pedestrian information by using an electric bulletin board or a blinking light mounted on the roadside device **20** so that the driver or assistant driver of the first vehicle **10** can easily perceive the pedestrian **60**.

[0057] The vehicle information may be corrected by the information processing device **30** based on the information of the first vehicle **10** and the second vehicle **50** detected from the video from the imaging unit **21** of the roadside device **20**. For example, two or more second vehicles (for example, large vehicles) may travel between the roadside device **20** and the first vehicle **10**, and vehicle information (for example, the number of the first vehicle **10** or the second vehicle **50**) acquired from the roadside device **20** and the first vehicle **10** may be inconsistent. In this case, the information processing device **30** may adopt the information of the first vehicle **10** and the information of the second vehicle **50** detected from the video from the imaging unit **21** of the roadside device **20** as the vehicle information. The information processing device **30** may further modify the vehicle information based on information acquired from a monitoring device such as another first vehicle **10**, another roadside device **20**, or a monitoring camera installed near the road. These monitoring devices may be present in a position in which all the first vehicles **10** and all the second vehicles **50** can be monitored. For example, two or more first vehicles **10** may travel on a plurality of lanes (e.g., oncoming lanes, two lanes on one side). Also, for example, two roadside devices **20** may be installed near both ends of the crosswalk.

Claims

1. A roadside device comprising: an imaging unit; a communication unit; a notification unit; and a control unit, wherein the control unit is configured to when a pedestrian near a road is detected from a video from the imaging unit, receive vehicle information from an information processing device via the communication unit, the vehicle information including relative position information between a first vehicle that is an autonomous vehicle approaching the roadside device and a second vehicle located around the first vehicle, and cause the notification unit to notify the pedestrian of notification information including the relative position information.

2. The roadside device according to claim 1, wherein the relative position information includes information indicating the number of the first vehicles and the second vehicles, information identifying that the first vehicle is an autonomous vehicle, and information indicating a position of the first vehicle with respect to the second vehicle as viewed from the roadside device.

3. The roadside device according to claim 1, wherein: the second vehicle is detected by a detection unit of the first vehicle; and the relative position information is calculated by a control unit of the information processing device based on information on the first vehicle and the second vehicle received by the information processing device from the first vehicle.

4. The roadside device according to claim 1, wherein the control unit is further configured to send pedestrian information on the pedestrian detected from the video from the imaging unit to a mobile terminal carried by a driver or an assistant driver of the first vehicle through the information processing device via the communication unit.

5. The roadside device according to claim 1, wherein the vehicle information is corrected by the

information processing device based on information on the first vehicle and the second vehicle detected from the video from the imaging unit.