An information providing device provided in a vehicle includes an object detecting unit for detecting an object outside the vehicle; a providing unit for providing, outside of the vehicle, visual information which is visually perceptible; and a controlling unit for controlling the providing unit. The providing unit is usually caused to provide the visual information to indicate a heading direction of the vehicle. In contrast, when the detected object is determined to include a danger to advancement of the vehicle or an indication of stopping the vehicle, the providing unit is caused to then move the visual information to indicate a direction towards the detected object.
FIG. 5

START

S10

DETECT SURROUNDING INFO.

S20

DETECT VEHICLE STATES

S30

GENERATE VEHICLE INFO.

S40

ESTIMATE DRIVER'S INTENTION

S50

ESTIMATE PATH

S60

CALCULATE PATH-TARGET

S70

DETERMINE DETECTED OBJECT

S80

DANGEROUS OBJECT?

NO

S90

GENERATE DANGER INFO.

S100

CALCULATE OBJECT-TARGET

S110

PROJECT VISUAL INFO.

END
INFORMATION PROVIDING DEVICE FOR VEHICLE

CROSS REFERENCE TO RELATED APPLICATION


FIELD OF THE INVENTION

[0002] The present invention relates to an information providing device for a vehicle.

BACKGROUND OF THE INVENTION

[0003] In JP-H10-255399-A, a conventional device is described which warns a vehicle’s driver of a dangerous object by illuminating the dangerous object using a spotlight or by projecting a warning sign to a position which is on the windshield of the vehicle and corresponds to a position of the dangerous object.

[0004] When the warning sign is shown on the windshield, the driver moves his/her sight line to the warning sign and adjusts his/her focus to the warning sign on the windshield to notice presence of the dangerous object. Subsequently, the driver adjusts his/her focus from the windshield to the dangerous object itself to estimate its distance from the vehicle. Thus, in a case where a warning sign is shown on the windshield, the driver needs to adjust his/her focus from the windshield to an actual position of a dangerous object in the process of noticing the dangerous object.

[0005] In addition, the device projects the spotlight only when it detects a dangerous object. Therefore, the driver possibly has difficulty in immediately reacting to the spotlight which comes up at an unexpected position. Moreover, a sight line of the driver and a heading direction of the vehicle are almost the same; therefore, the driver possibly fails to recognize the spotlight if the spotlight deviates from the heading direction.

[0006] Thus, using the conventional device, the driver sometimes has difficulty in recognizing a dangerous object even in a case where the driver needs to react against the dangerous object as quickly as possible.

SUMMARY OF THE INVENTION

[0007] It is therefore an object of the present invention to provide an information providing device which enables a driver to quickly react to a dangerous object.

[0008] To achieve the above object, an information providing device in a vehicle is provided with the following. An object detecting unit is included for detecting an object outside the vehicle. A providing unit is included for providing, outside the vehicle, visual information which is visually perceptible. Furthermore, a controlling unit is included for controlling the providing unit. Here, the providing unit is usually caused to provide the visual information to indicate a heading direction of the vehicle. In contrast, when the detected object is determined to include a danger to advancement of the vehicle or an indication of stopping the vehicle, the providing unit is caused to move the visual information to indicate a direction towards the detected object.

[0009] Under the above structure, the information providing device can usually lead a driver’s sight line to the heading direction of the vehicle. Thus, driver’s eyes can focus on the heading direction, which is proper for usual driving operation. In addition, when the detected object is determined to be requiring driver’s attention, the visual information is moved while continuing to be perceptible so that the detected object can be indicated by the moved visual information.

[0010] Thus, the driver watching the heading direction notices the movement of the visual information and the sight line of the driver is led to the detected object by following the movement. Consequently, this helps prevent a delay in movement of the sight line or an oversight of the dangerous object.

[0011] Furthermore, when the visual information moves from the heading direction to the direction towards the detected dangerous object, the focus of the driver changes also from the heading direction to the direction towards the detected object, within scenery outside of the vehicle. Therefore, an amount of adjustment of the focus in this case using the device of the present invention is small compared to that in a case using the conventional device where the focus moves from the windshield of the vehicle to the dangerous object outside the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The above and other objects, features, and advantages of the present invention will become more apparent from the following detailed description made with reference to the accompanying drawings. In the drawings:

[0013] FIG. 1 shows a structure of an information providing device for a vehicle;

[0014] FIG. 2 shows a diagram of units included in a controller in the information providing device;

[0015] FIG. 3 shows a situation where the information providing device projects visual information of an estimated path for a subject vehicle;

[0016] FIG. 4 shows a situation where the information providing device projects visual information of danger information towards a dangerous object; and

[0017] FIG. 5 shows a flowchart of a process which the controller executes.

DETAILED DESCRIPTION OF THE INVENTION

[0018] As shown in FIG. 1, an information providing device 100 mounted in a subject vehicle includes surrounding information detectors 10, driving operation state detectors 20, vehicle running state detectors 30, a controller 40, and a laser projection device 50.

[0019] The surrounding information detectors 10 include a laser or radar sensor, an image sensor, an ultrasonic sensor, and a navigation device. Using the detectors 10, the controller 40 detects characteristics of an object located outside the vehicle, specifically, forward, sideward, and rearward of the vehicle. The detected characteristics of the object include, with respect to the object, a kind, a position, a heading direction, or a relative velocity relative to the
vehicle. The kind of the object is, for example, another vehicle (further, a passenger automobile, a truck, a two-wheeled motorcycle, or the like), a pedestrian, a traffic control device, a road traffic sign, or a lane marker or a border between lanes on a road (e.g., a white line, a yellow line, or a central reserve).

[0020] The laser or radar sensor irradiates an area within a predetermined distance outside the vehicle using laser beams or the like and calculates a distance from the vehicle, a velocity relative to the vehicle, and a direction as seen from the vehicle, with respect to the object which reflects the laser beams or the like. Then the laser or radar sensor outputs the calculated values as electric signals to the controller 40.

[0021] The image sensor includes an optical camera which operates as an imaging unit for photographing an area forward, sideward, or rearward of the vehicle to take an image. According to the image, the image sensor detects characteristics of an object in the image and outputs the characteristics as electric signals to the controller 40. The characteristics include a kind, a size, and a state (e.g., a lighting color of a traffic light), with respect to the object.

[0022] The ultrasonic sensor sends ultrasonic sound waves to locations surrounding the vehicle. The locations are about several meters away from the vehicle. Then the ultrasonic sensor detects a distance between the vehicle and the object which reflects the ultrasonic sound waves, and outputs the detected distance as electric signals to the controller 40.

[0023] The navigation device displays a map around a current position of the vehicle, finds an optimum route to a destination, and shows the route to a driver of the vehicle.

[0024] In addition, the navigation device has a storage device memorizing map data which includes roads data (e.g., data regarding road traffic signs and traffic control devices) and facilities data. The roads data includes, for example, data regarding locations or kinds of road signs, data regarding locations of traffic control devices relative to intersections or crosswalks, and data regarding kinds or shapes of traffic control devices.

[0025] Moreover, the navigation device detects a current position of the vehicle and outputs information such as a kind and a distance of a structure on a road within a predetermined distance from the current position. The structure is, for example, a traffic control device and a traffic sign which directs or indicates a vehicle to stop or go.

[0026] The driving operation state detectors 20 include a throttle sensor, a brake sensor, a steering sensor, a shift state sensor, and a turn signal state sensor, which are not illustrated, and outputs detection signals of each sensor to the controller 40.

[0027] The throttle sensor detects a throttle position depending on an amount of operation of a throttle pedal. The brake sensor detects a depression force of a brake pedal. The steering sensor detects a direction of operation of a steering wheel and an amount of rotation of the steering wheel relative to the central position. The turn signal state sensor detects a direction (i.e., right or left) indicated by a turn signal.

[0028] The vehicle running state detectors 30 include a speed sensor, an acceleration sensor, a yaw rate sensor, a tire direction sensor, and a wheel loading sensor, which are not illustrated, and outputs detection signals of each sensor to the controller 40.

[0029] The speed sensor is a wheel speed sensor which detects speed of the vehicle. The acceleration sensor detects acceleration of the vehicle in the anteroposterior direction, the lateral direction, and the vertical direction. The tire direction sensor detects a turn angle of a vehicle wheel around a vertical axis against a reference angle that is an angle of the wheel when the vehicle is going in a straight line. The turn angle to be detected depends on operation of a steering wheel. Therefore, the turn angle can be also detected by the steering sensor. The wheel loading sensor detects a load on each wheel suspension of the vehicle along the vertical direction.

[0030] The laser projection device 50 radiates laser beams to provide or project visual information by irradiating a target position or a target object outside the vehicle. Here, the irradiated target position or object can be seen through the projected transparent visual information. Thus, the driver can view a surrounding area and the visual information as a part of the surrounding areas. The laser projection device 50 is controlled by the controller 50 as described below.

[0031] The controller 40 is a microcomputer which has a CPU, a RAM, a ROM, and an input/output interface, which are not illustrated.

[0032] As shown in FIG. 2, the controller 40 includes a surrounding information detection unit 41, a driving operation information generation unit 42, a running information generation unit 43, a driver intention estimation unit 44, a path estimation unit 45, a danger determination unit 46, an object projection calculation unit 47, and a path projection calculation unit 48. Here, the CPU achieves the above units by executing programs corresponding to the units, by reading the programs from the ROM and using the RAM as a work area.

[0033] The surrounding information detection unit 41 detects surrounding information relating to an object surrounding the vehicle, by comprehensively considering the signals from the surrounding information detectors 10. Here, the object is, for example, another vehicle (a passenger automobile, a truck, a two-wheeled motorcycle, or the like), a pedestrian, a traffic control device, a road traffic sign, or a lane marker or a border between lanes on a road (e.g., a white line, a yellow line, or a central reserve). The surrounding information with respect to the object includes a kind, a position, a heading direction, and a relative velocity to the vehicle. The detected surrounding information is used by the danger determination unit 46 and the object projection calculation unit 47.

[0034] The driving operation information generation unit 42 generates, based on the detection signals from the driving operation state detectors 20, driving operation information which indicates a state of driving operation by the driver. The driving operation information is used by the driver intention estimation unit 44.

[0035] The driver intention estimation unit 44 estimates, based on the generated driving operation information, driver's intention regarding driving operation such as starting, accelerating, changing lanes, turning left/right, decelerating, or stopping. Driver intention information which indicates
the estimated driver’s intention is used by the danger determination unit 46 and the path target calculation unit 48.

[0036] The running information generation unit 43 generates, based on the detection signals from the vehicle running state detectors 30, running information which indicates a state of movement of the vehicle. The driving operation information is used by the path estimation unit 45.

[0037] The path estimation unit 45 estimates, based on the generated running information, an estimated path which the vehicle is estimated or expected to follow. In detail, the path estimation unit 45 applies the running information to parameters in a predetermined movement model of the subject vehicle to obtain the estimated path. Information on the estimated path is used by the danger determination unit 46 and the path projection calculation unit 48.

[0038] The danger determination unit 46 determines whether the detected object is dangerous to advancement of the vehicle and whether the detected structure on a road indicates the vehicle to stop. Such an indication is made, for example, by a stop signal from a traffic control device and a brief stop sign on a road. In addition, the unit 46 determines a danger level (e.g., high or low) of the detected object depending on a distance between the detected object and the vehicle.

[0039] The determination is executed based on the surrounding information, the driver intention information, and the information on the estimated path. However, the determination can be executed without the driver intention information. The determination can be also executed without the information on the estimated path.

[0040] When the unit 46 determines that the object is dangerous to advancement of the vehicle or that the structure indicates the vehicle to stop, it generates danger information which includes a kind, a relative position to the vehicle, and a danger level, with respect to the object or the structure (hereafter dangerous object). The danger information is used by the object projection calculation unit 47.

[0041] The path projection calculation unit 48 calculates path-target positions (e.g., directions and/or distances) to irradiate using laser beams. The path-target positions correspond to an estimated path from a current position of the vehicle to a position which the vehicle is estimated to reach after a period (e.g., 3 seconds) by following the estimated path. The unit 48 outputs the calculated path-target positions to the laser projection device 50.

[0042] While the vehicle is running, the laser projection device 50 usually provides or projects an estimated path LL, LR (in FIG. 3) of the visual information toward the heading direction of the vehicle as seen from the driver. Therefore, the information providing device 100 can lead the driver’s sight line to the path-target positions of the estimated path.

[0043] In addition, the path projection calculation unit 48 may change the way of the projection, based on the running information (e.g., a speed of the vehicle and an amount of rotation of the steering wheel), by changing at least one of a direction, a length, and a shape, with respect to the projection.

[0044] The driver generally has difficulty in properly maintaining his/her sight line or focus when his/her arousal level is reduced. In this case, characterless and unchanging visual information possibly decreases his/her arousal level further and causes his/her lack of attention. As a result, the driver possibly overlooks information necessary for driving the vehicle, or fails to react to the information in time.

[0045] Therefore, the change of the way of the projection based on the running state of the vehicle gives variations to the visual information, and possibly suppresses the reduction of the arousal level.

[0046] The object projection calculation unit 47 calculates object-target positions (e.g., directions and/or distances) that enable visual information as the danger information to indicate the dangerous object itself and a direction towards a position of the dangerous object, when the unit 46 generates the danger information. The object projection calculation unit 47 moves the estimated path of the visual information from the lines LL, LR in FIG. 3 to lines LT, LT in FIG. 4 that correspond to the calculated object-target positions.

[0047] The object projection calculation unit 47 also determines the way of projection so that the laser projection device 50 can provide the visual information corresponding to the kind of the dangerous object. For example, when the danger information indicates that the dangerous object is a nearby vehicle or a pedestrian, the unit 47 determines the way of projection so that the projected visual information as the danger information includes a shape of an exclamation mark in addition to the lines LT, LT, as seen in FIG. 4.

[0048] The controller 40 operates as shown in FIG. 5 as a whole. First, the controller 40 detects the surrounding information using the surrounding information detection unit 41 at Step S10.

[0049] At Step S20, vehicle states of the driving operation state and the vehicle running state are detected using the driving operation information generation unit 42 and the running information generation unit 43, respectively. At Step S30, vehicle information of the driving operation information and the running information is then generated based on the detections of Step S20 also using the driving operation information generation unit 42 and the running information generation unit 43, respectively.

[0050] Subsequently, at Step S40, the driver’s intention is estimated based on the driving operation information using the driver intention estimation unit 44. Step S50, the estimated path is estimated based on the running information using the path estimation unit 45. At Step S60, the path-target positions are calculated for providing the visual information regarding the estimated path using the path projection calculation unit 48.

[0051] Then, at Step S70, the detected object or structure is determined to be the dangerous object or not; namely, it is determined whether the detected object is dangerous to advancement of the vehicle and whether the detected structure on a road indicates the vehicle to stop, using the danger determination unit 46. Then, at Step S80, it is determined whether there is a dangerous object outside the vehicle also using the danger determination unit 46.

[0052] When the determination of Step S80 is negated, Step S110 takes place. Here, the controller 40 causes the laser projection device 50 to project the estimated path of the
lines LL, LR towards the heading direction of the vehicle which is calculated at Step S60, as shown in FIG. 3.

[0053] In contrast, when the determination at Step S80 is affirmed, the danger information is generated at Step S90. At Step S100, the object-target positions and the way of the projection are calculated for providing the visual information of the danger information regarding the dangerous object using the object projection calculation unit 47. After Step S100, Step S110 takes place. Here, the controller 40 causes the laser projection device 50 to move the visual information of the estimated path from the lines LL, LR shown in FIG. 3 to the lines LT, LT including the exclamation mark shown in FIG. 4, based on the object-target positions and way of the projection calculated at Step 100.

[0054] By executing Steps S10 to S110, the information providing device 100 continuously projects the estimated path as the visual information toward the heading direction of the vehicle while a dangerous object is not around the vehicle. Once the dangerous object appears, the information providing device 100 starts to move the projected estimated path from the positions of the lines LL, LR in FIG. 3 to the positions of the lines LT, LT in FIG. 4 that is approaching the dangerous object. During this movement, the lines continue being projected on a relevant road.

[0055] Thus, the driver can smoothly follow the movement of the lines of the estimated path as the visual information. Therefore, the delay of movement of the driver’s sight line can be suppressed, and the oversight of the dangerous object can be reduced.

[0056] The present invention should not be limited to the embodiment discussed above and shown in the figures, but may be implemented in various ways without departing from the spirit of the invention.

[0057] For example, the information providing device 100 may project visual information on a lane maker between two lanes of a road when the vehicle is about to deviate from one of the lanes to the other. Thus, the device 100 can draw the driver’s attention to the situation.

[0058] In addition, the information providing device 100 may have a monitoring unit for monitoring a sight line of the driver. In this case, when the device 100 detects, using the monitoring unit, that the driver is looking aside, it can provide the visual information such as an exclamation mark by irradiating the location which the driver is looking at. Thus, the device 100 can urge the driver to gaze at a proper direction for driving.

[0059] In addition, the device 100 may retrieve a route, which the vehicle should go along, from the navigation device and provide visual information indicating a direction along the route by irradiating positions in the direction. Thus, the device 100 can provide the information of the route to the driver.

[0060] In addition, when the vehicle is about to enter a blind intersection, the device 100 may project visual information on an approaching vehicle to notify the approaching vehicle of presence of the vehicle where the device 100 is mounted.

[0061] In addition, the device 100 may project visual information on a pedestrian who is determined to be not a dangerous object but to be present in front of the vehicle. Thus, the device 100 can notify the pedestrian of presence of the approaching vehicle.

[0062] In addition, the device 100 may project visual information indicating an intention of changing to an adjacent lane, in conjunction with operation of a turn signal switch and an amount of rotation of the steering wheel. Thus, the device 100 can notify following vehicles in the adjacent lane of the intention of changing lanes of the vehicle where the device 100 is mounted.

[0063] In addition, the device 100 does not need to always project visual information toward the heading direction while a dangerous object is not present around the vehicle. The device 100 may need to project the visual information toward the heading direction at a certain period just before the projected visual information starts to move to the detected dangerous object.

What is claimed is:

1. An information providing device provided in a vehicle, the device comprising:
   - an object detecting unit for detecting an object outside the vehicle;
   - a providing unit for providing, outside of the vehicle, visual information which is visually perceptible; and
   - a controlling unit for causing the providing unit to provide the visual information to indicate a heading direction of the vehicle and to move the visual information to indicate a direction towards the detected object when the detected object is determined to include at least one of (i) a danger to advancement of the vehicle and (ii) an indication of stopping the vehicle.

2. The information providing device of claim 1, further comprising:
   - a running state detecting unit for detecting a running state of the vehicle, wherein the controlling unit estimates a path which the vehicle is estimated to follow according to the detected running state and causes the providing unit to provide the visual information that shows the estimated path to indicate the heading direction of the vehicle.

3. The information providing device of claim 2, wherein the controlling unit changes, with respect to the shown estimated path, at least one of a direction, a length, and a shape, based on the detected running state.

4. The information providing device of claim 1, further comprising:
   - a running state detecting unit for detecting a running state of the vehicle, wherein the controlling unit estimates a path which the vehicle is estimated to follow based on the detected running state and
determines whether the detected object includes at least one of the danger to advancement of the vehicle and the indication of stopping the vehicle, based on the estimated path.

5. The information providing device of claim 1, further comprising:
   a driving operation state detecting unit for detecting a driving operation state of a driver of the vehicle, wherein the controlling unit
   estimates intention of the driver regarding the driving operation based on the detected driving operation state,
   determines whether the detected object includes at least one of the danger to advancement of the vehicle and the indication of stopping the vehicle, based on the estimated intention.

6. The information providing device of claim 1, wherein the object detecting unit detects at least one of another vehicle, a pedestrian, a traffic control device, a road traffic sign, and a boarder between lanes of a road, and
   wherein, when the providing unit is caused to move the visual information to indicate the direction towards the detected object, the providing unit provides the visual information which varies depending on a kind of a detected object by the object detecting unit.

7. The information providing device of claim 1, wherein the providing unit provides the visual information that is formed using laser beams.

8. An information providing method used in a vehicle, the vehicle including:
   an object detecting unit for detecting an object outside the vehicle; and
   a providing unit for providing, outside of the vehicle, visual information which is visually perceptible,
   the information providing method comprising steps of:
   causing the providing unit to provide the visual information to indicate a heading direction of the vehicle;
   executing a determination of whether or not the detected object includes at least one of (i) a danger to advancement of the vehicle and (ii) an indication of stopping the vehicle; and
   causing the providing unit to move the visual information to indicate a direction towards the detected object, when the determination is affirmed.

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