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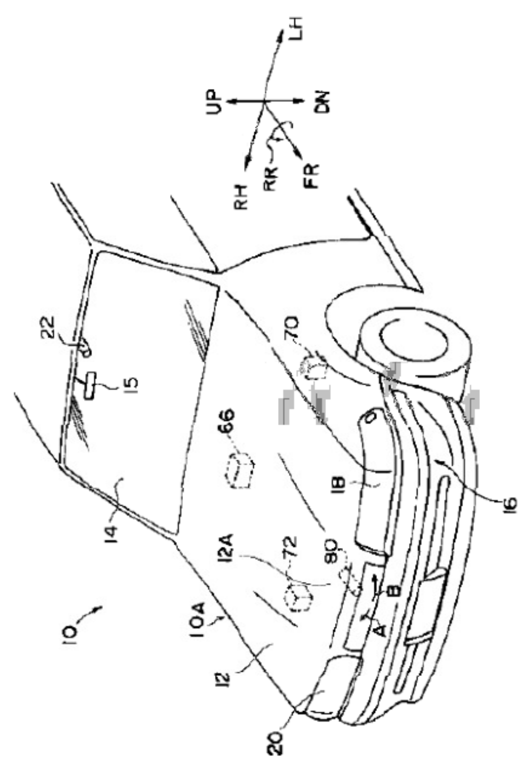
(54) [Title of the invention] Headlamp Device for Vehicle

(57)[Abstract]
[Object] To reliably prevent the creation of glare on other vehicles.
[Structure] A TV camera 22 that images the conditions ahead of a vehicle and a radar 80 that measures inter-vehicle distance to another vehicle is mounted in a vehicle 10. The radar 80 is rotated in the direction of arrow A or in the direction of arrow B by actuators (not pictured). Based on the image signals output from the TV camera 22, another vehicle is recognized by an image processing device (not pictured), and the position of each vehicle in the image is determined. Next, based on the position of each vehicle that has been determined, the direction in which each vehicle is present is found, the radar 80 is rotated so that the other vehicle is contained within the radar 80 detection area, and the inter-vehicle distance to each vehicle is measured. Additionally, based on the measured inter-vehicle distances, a light-shielding cam (not shown) provided on a headlamp 18, 20 is rotated, thereby controlling the illumination range of the lamps so as not to create glare on other vehicles.



[Claims]
[Claim 1]
A headlamp device for a vehicle having:
a headlamp, at least one of illumination direction and illumination range thereof being changeable;
an imaging means that images the conditions ahead of a vehicle and outputs image signals;
a detecting means that, based on image signals output from said imaging means, detects the direction in which another vehicle is present;
a measuring means that, based on the direction of another vehicle detected by said detecting means, measures an inter-vehicle distance to said another vehicle; and,
a controlling means that, based on at least the inter-vehicle distance to said another vehicle measured by said measuring means, controls at least one of illumination direction and illumination range of said headlamp so as not to create glare on said another vehicle.
[Detailed description of the invention]
[0001]
[Field of industrial use] The present invention relates to a headlamp device for a vehicle, and in particular, to a headlamp device for a vehicle that, while a vehicle is traveling, controls the light distribution of a headlamp that illuminates the area ahead of a vehicle.
[0002]
[Prior art] Headlamps are placed as a pair on the right side and left side of the front end of a vehicle, and light up in cases in which it is difficult to view the conditions ahead such as at night, thereby enhancing a driver's forward visibility. These headlamps generally are configured so as to be switchable between only two stages of illumination range, high beam and low beam, and in cases in which other vehicles such as leading vehicles or oncoming vehicles are present, low beam is often selected so as not to create a glare that is blinding and discomforting to drivers of other vehicles. Nonetheless, in cases in which the inter-vehicle distance to a leading vehicle is long, for example, there is the problem that with low beam, a driver continuously sees dark portions outside the illumination range of the headlamps, and with high beam, glare is created on leading vehicles and the like, thereby making it difficult to illuminate the area ahead within an appropriate range constantly.
[0003] Therefore, it has been proposed that a visor for shielding illuminating light is provided inside a headlamp, said visor being moved so as not to create glare on other vehicles and also so as a sufficient illumination range can be obtained, thereby controlling the position of the boundary between an illuminated area and a not-yet-illuminated area (hereinafter, this boundary is called a cutoff line). Further, it has been proposed, as a technology to control the position of the cutoff line so as not to create glare on other vehicles, that the conditions ahead of a vehicle is imaged by a CCD camera or the like; a leading vehicle is recognized and the inter-vehicle distance to the leading vehicle is detected based on image signals output from the CCD camera; and the headlamp light distribution is controlled according to the inter-vehicle distance (See Japanese Unexamined Patent Application Publication S62-131837).
[0004] Detection of inter-vehicle distance based on images representing the conditions ahead of a vehicle is performed based on the principle that as the inter-vehicle distance to another vehicle increases, the position of the other vehicle in said image moves toward the top of the image, and the farther toward the top of the image the other vehicle is positioned, the greater the inter-vehicle distance is judged to be. Further, since it is difficult to detect other vehicles themselves in conditions such as at night, if a leading vehicle, tail lamps, and if an oncoming vehicle, headlamps, are detected, and inter-vehicle distance is judged based on the height position of the lamps or the interval between the lamps in the image.
[0005]
[Problems the invention is to solve] Nonetheless, the height position of said tail lamps and headlamps relative to the road surface and the interval between the lamps vary by vehicle model. Therefore, in detecting inter-vehicle distance based on the height position of tail lamps or headlamps, or the interval between lamps, even if the actual inter-vehicle distance is the same, the inter-vehicle distance detection results can vary according to the vehicle model of the other vehicle. Further, the height position of lamps in an image will change in cases in which, for example, the relative height position relative to other vehicles changes due to the incline of the road surface or the like. Accordingly, inter-vehicle distance cannot be detected accurately by the lamp height position and lamp interval in an image, and thus there is a possibility of creating glare on other vehicles even if headlamp light distribution is controlled based on the detected inter-vehicle distance to other vehicles.
[0006] The present invention was created with consideration of the aforementioned situations, and an object thereof is to obtain a headlamp device for a vehicle that can reliably prevent the creation of glare on another vehicle.
[0007]
[Means for solving the problems] In order to achieve the above object, the headlamp device for a vehicle has: a headlamp, at least one of illumination direction and illumination range thereof being changeable; an imaging means that images the conditions ahead of a vehicle and outputs image signals; a detection means that, based on image signals output from said imaging means, detects the direction in which another vehicle is present; a measuring means that, based on the direction of another vehicle detected by said detecting means, measures an inter-vehicle distance to said another vehicle; and a controlling means that, based on at least the inter-vehicle distance to said another vehicle measured by said measuring means, controls at least one of illumination direction and illumination range of said headlamp so as not to create glare on said another vehicle.
[0008]
[Function] In the present invention, the direction in which another vehicle is present is detected based on image signals obtained by imaging conditions ahead of a vehicle, the inter-vehicle distance to another vehicle based on the detected direction of another vehicle is measured by a measuring means, and at least based on the inter-vehicle distance to another vehicle, at least of one of illumination direction and illumination range of the headlamps is controlled so as not to create glare on another vehicle. Commonly known millimeter wave radar, laser radar and the like, for example, can be applied as said measuring means. Further, it is also possible to apply, for example, a geodimeter, which measures distance using light interference and is used in surveying and the like; or a Tellurometer, which measures the round-trip time for microwaves reflected from a measurement target and finds distance based on phase comparison.

[0009] The aforementioned measuring means, because the detection value of inter-vehicle distance does not vary due to the vehicle model of the vehicle that is the detection target or due to changes in the relative height relative to the vehicle that is the detection target, can accurately measure inter-vehicle distance by detecting the lamp height position or lamp interval in an image and comparing this to cases in which the inter-vehicle distance to another vehicle is judged or the like, and based on this accurately measured inter-vehicle distance, by controlling at least one of illumination direction and illumination range of the headlamps, can prevent creation of glare on another vehicle.

[0010] Moreover, in cases in which radar is used as a measuring means to detect inter-vehicle distance to another vehicle, said inter-vehicle distance to another vehicle can be measured by using a radar with a relatively small output and sharp directivity, for example, and by orienting the radar so that another vehicle whose position has been detected falls within the detection range of the radar. Further, it is also acceptable to obtain the inter-vehicle distance of a specific other vehicle based on the position of the other vehicle after the distance relative to all objects present in said detection range has been detected using a radar with a relatively large output and broad detection range. Nonetheless, because it is desirable for a measuring means to be installed in a vehicle to be compact and inexpensive, and because its output cannot be very large, it is preferable to use a radar with a relatively small output and sharp directivity to detect inter-vehicle distance, as discussed previously.

[0011]

[Embodiments]

Hereinafter, an embodiment of the present invention is described in detail with reference to drawings. As shown in Figure 1, an engine hood 12 is disposed on the top surface of the front body 10A of a vehicle 10, and a front bumper 16 is affixed to the front end of the front body 10A across the width of the vehicle from one end to the other end. A pair of headlamps 18, 20 is disposed at each end of the width of the vehicle, between the front bumper 16 and the front edge of the engine hood 12.

[0012]

A windshield glass 14 is provided near the back edge of the engine hood 12, and a room mirror 15 is provided in proximity to the portion corresponding to the top of the windshield glass 14 on the inside of the vehicle 10. A TV camera 22 for imaging the conditions ahead of a vehicle is disposed in proximity to the room mirror 15. The TV camera 22 is connected to an image processing device 48 (see Figure 4). In the present embodiment, a TV camera equipped with a CCD element that simply detects only the amount of light and outputs image signals representing black-and-white images is used as the TV camera 22.

[0013] The TV camera 22 is preferably disposed in a position as close as possible to the driver perspective (the "eye point") so that the configuration of the road ahead of the vehicle can be accurately recognized and the visual sensation of the driver can be more closely matched. Further, the configuration of the road in the present embodiment includes the configuration of the path of travel, for example, a road configuration corresponding to a one-vehicle lane formed by a center line or a curb, etc. Further, a speedometer (not pictured) is placed in the vehicle 10, and a vehicle speed sensor 66 (see Figure 4) that detects the vehicle speed V of the vehicle 10 is attached to the cable of the speedometer not image processing device 48 and outputs the vehicle speed V detection results.

[0014] Further, a radar 80 is disposed as a measuring means on the inside of the front grill of the vehicle 10. In the present embodiment, a millimeter radar with a detection range width approximately the size of one lane travelled by a vehicle is used as the radar 80. An actuator 82 (see Figure 4) that rotates the radar 80 in the direction of arrow A and the direction of arrow B in Figure 1 is coupled to the radar 80. Rotation of radar 80 by the actuator 82 in the direction of arrow A or the direction of arrow B in Figure 1 contains another vehicle present in any direction ahead of the vehicle 10 within the detection area and allows detection of the inter-vehicle distance to the other vehicle. The radar 80 is connected to an input port 58 of a control device 50 (see Figure 4) and outputs the result of inter-vehicle distance detection to the control device 50. Further, said actuator 82 is connected to an output port 64 of the control device 50 and rotates the radar 80 in the direction of arrow A or the direction of arrow B by just the rotation angle instructed by the control device 50.

[0015] As shown in Figure 2 and Figure 3, the headlamp 18 is a projector-type headlamp equipped with a convex lens 30, a bulb 32, and a lamp housing 34. The lamp housing 34 is fixed generally horizontally to the frame (not pictured) of the vehicle 10, the convex lens 30 is fixed to one of the lamp housing 34 openings, and at another opening bulb 32 is affixed via a socket 36 such that its illumination spot is positioned on the optical axis L of the convex lens 30 (the central axis of the convex lens 30).

[0016] A reflector 38 with an elliptical reflective surface is formed on the bulb side of the interior of the lamp housing 34, and light emitted from the bulb 38 [sic] is reflected by the reflector 38 and focused between the convex lens 30 and the bulb 32. Actuators 40, 42 are placed in proximity to the focal point. An actuator 40 is equipped with a light-shielding cam 40A with the axle thereof supported rotatably around a rotational axis 44 fixed inside the lamp housing 34 along the width of the vehicle, and a gear 40B is secured to the light-shielding cam 40A. A gear 40C secured to the drive axle of a motor 40D engages the aforementioned gear 40B. The motor 40D is connected to a driver 64 of the control device 50.

[0017] Further, the actuator 42, like the actuator 40, comprises a light-shielding cam 42A with the axle thereof supported rotatably around said rotational axis 44, a gear 40B secured to the light-shielding cam 40A [sic], a motor 42D, and a gear 40C [sic] which is secured to the drive axle of the motor 42D and engages the aforementioned gear 40B [sic]. The motor 40D [sic] is also connected to the driver 64 of the control device 50. The light of the bulb 32 reflected and focused by the reflector 38 is shielded by the light-shielding cams 40A, 42A of the actuators 40, 42, and all other light is projected from the convex lens 30.

[0018] Said light-shielding cams 40A, 42A have a cam shape wherein the distance from the rotational axis 44 to the outer boundary changes continuously along the circumferential direction, and are rotated individually by the motors 40D, 42D operated according to signals from the control device 50. The position of the boundary where the light of the bulb 32 is divided into transmitted light and shielded light is changed vertically according to the rotation of the light-shielding cams 40A, 42A. This boundary appears as the cutoff line that is the boundary between light and dark of the light distribution ahead the vehicle 10.

[0019] As shown in Figure 22, said boundary formed by the light-shielding cam 40A appears as a cutoff line 70 on the right side of the vehicle width within the area illuminated by the headlamp 18, and by rotating the light-shielding cam 40A, the position of the cutoff line 70 moves in parallel from the position corresponding to the highest position (in Figure 22, the position shown by a solid line as the cutoff line 70, a position at or lower than the so-called high beam) to the position corresponding to the lowest position (in Figure 22, the position shown by an imaginary line, a position along the so-called low beam).

[0020] Further, said boundary formed by the light-shielding cam 42A appears as the cutoff line 72 on the left side of the vehicle width within the illuminated area, and by rotating the light-shielding cam 42A, the position of the cutoff line 72 moves in parallel from the highest position (in Figure 22, the position shown by a solid line as the cutoff line 72, a position at or lower than the so-called high beam) to the lowest position (in Figure 22, the position shown by an imaginary line, a position along the so-called low beam).

[0021] Further, because the headlamp 20 has the same configuration as the headlamp 18, a detailed description is omitted, but, as shown in Figure 4, actuators 41, 43 are attached, and the position of the cutoff line on the left side and the position of the cutoff line on right side of the illuminated area respectively is moved independently according to operation of the actuators 41, 43.

[0022] As shown in Figure 4, the control device 50 is configured by containing a read-only memory (ROM) 52; a random access memory (RAM) 54; a central processing device (CPU) 56; an input port 58; an output port 60; and a data bus, control bus, or other such bus 62 that connects the aforementioned components. Moreover, a map and a control program, discussed below, are stored in said ROM 52.

[0023] The vehicle speed sensor 66 and the image processing device 48 are connected to the input port 58. As discussed below, the image processing device 48 performs image processing of images made by the TV camera 22 based on signals input from the TV camera 22 and the control device 50. The output port 60 is connected via the driver 64 to the actuators 40, 42 of the headlamp 18 and the actuators 41, 43 of the headlamp 20. Further, the output port 60 is also connected to the image processing device 48.

[0024] Next, the function of the present embodiment is described with reference to the flow charts of Figure 5 through Figure 7. When a driver turns on the light switch (not pictured) in the vehicle 10, thereby lighting the headlamps 18, 20, the main control routine shown in Figure 5 is implemented at predetermined time intervals. In Step 200 of the main control routine, leading vehicle recognition processing is performed, and a leading vehicle driving ahead of the host processing is described with reference to the flow chart in Figure 6.

[0025] An example image (image 120) imaged by the TV camera 22 while the vehicle 10 is traveling on a road 122 and that generally matches the image visible to the driver is shown in Figure 8(A). The road 122 is provided with a white line 124 on both sides of the lane in which the vehicle 10 is traveling. The position of each pixel in the above-mentioned image is specified by coordinate system coordinates (X_n, Y_n) determined by the intersection of the X-axis and Y-axis set on the image. Next, recognition of another vehicle, including a leading vehicle, is performed based on this image.

[0026] In Step 300 of the flow chart of Figure 7, an area having a predetermined width γ on the image as shown in Figure 9 is set as a white line detection window area Wsd. In the present embodiment, when the vehicle 10 is traveling at night, in consideration of the fact that an image can only be detected up to about 40-50m ahead of the vehicle 10, white line detection is not performed at distances exceeding 60m ahead of the vehicle 10. Further, the probability that a leading vehicle will be present in the lower area of an image is low. Therefore, the white line detection window area Wsd, so as to make detection up to 60m ahead of the vehicle 10 possible, is set as a white line detection window area Wsd with the area above a predetermined horizontal line 140 and the area below a lower limit line 130 removed.

[0027] Next, in Step 302, content in the window area Wsd is differentiated for brightness, and the peak point (maximum point) of these derivatives is extracted as an edge point that is a white line candidate point. That is, in the window area W sd, brightness is differentiated for each pixel in a vertical direction (direction of arrow A in Figure 9) and a horizontal direction from the lowest position pixel to the highest position pixel, and the peak points of derivatives with a large variation in brightness are extracted as edge points. Thus, as an example, continuous edge points are extracted as shown by the dotted line within the window area Wsd of Figure 9.

[0028] In Step 304, straight line approximation processing is performed. This processing approximates straight lines by using Hough conversion to convert the edge points extracted in white line candidate extraction processing, and approximate straight lines 142, 144 along the line assumed to be a white line are found. Next, Step 305 finds the point of intersection P_N (where X coordinate value = X_N) for the approximate straight lines thus determined, as well as the horizontal displacement A (A = XN - X0) of the point of intersection P_N thus determined from a point of intersection P_O (where X coordinate value = X_O) for an approximate straight line in the case of a straight road, determined in advance as a reference. This displacement amount A corresponds to the degree of curve of the road 122.

[0029] Next, in Step 306, it is judged whether or not the road 122 is a generally straight road by judging whether or not the displacement amount A is within the range of $A2 \geqq A \geqq A1$. The judgment reference value A1 is a reference value representing the boundary between a straight road and a right-curving road, and the judgment reference value A2 is a reference value representing the boundary between a straight road and a left-curving road. In cases in which a straight road is judged in Step 306, the vehicle speed of the host vehicle 10 is read out in Step 308.

[0030] Next, in Step 310, correction widths αL, αR that correct the position of the approximate straight lines are determined by setting a leading vehicle recognition area WP that recognizes leading vehicles corresponding to the read-out vehicle speed V. Because the radius of curvature of a road on which a vehicle can turn when traveling at high speeds is large, travel on a generally straight road is an allowable approximation, but because the radius of curvature when traveling at low speeds is small, even if the road directly ahead of the vehicle is close to a generally straight road, in cases in which the radius of curvature of the road far ahead is decreasing, it is possible that the vehicle may deviate from the leading vehicle recognition area WP. Therefore, using a map such as the one shown in Figure 12, the values of said correction widths αL, αR are determined so as to increase as vehicle speed V decreases.

[0031] Next, in Step 312, the area enclosed by the lower limit line 130 and the approximate straight lines 142, 144 with their positions corrected by corrections widths αL, αR is set as the leading vehicle recognition area WP (see Figure 10). Moreover, for this leading vehicle recognition area WP as well, as travel speed decreases and correction widths αL, αR change in response to changes in vehicle speed V, the area is made larger (see Figure 11).

[0032] On the other hand, when judgment is negative in Step 306, in Step 314, by judging whether or not $A > A2$, it is judged whether the road is a right-curving road or a left-curving road. In cases in which judgment is positive, the road is judged to be a right-curving road; the vehicle speed V of the vehicle 10 is read out in Step 316; and in Step 318, the correction values αL', αR' for the correction widths αL, αR that correspond to the read-out vehicle speed V are determined using the map shown in Figure 12. Next, in Step 320, the maps in Figure 13 and Figure 14 are used to determine gains G_L, G_R for determining corrections widths αR, αL for left and right approximate straight lines that correspond to the displacement amount A that represents the degree of curvature. In Step 322, final left and right correction widths for the window area are determined based on the correction values αR', αL' and gains G_L, G_R as determined.

[0033] Because the road in this instance is a curved road, it is left-right asymmetrical, and the approximate straight lines 142, 144 have different inclinations. Thus, the left and right correction widths αR, αL are set as independent values. That is, when the road is a right-curving road with a small radius of curvature (large displacement amount A), the likelihood that a leading vehicle is present on the right side is high. Accordingly, the correction width αR is increased by increasing the right side gain G_R (see Figure 13), and the correction width αL is decreased by decreasing the left side

displacement amount A), the correction width αR is decreased by decreasing the right side gain G_R, and the correction width αL is increased by increasing the left side gain G_L. This change in correction width is shown as an image in Figure 15.

[0034] In Step 324, the area enclosed by the approximate straight lines 142, 144 with their positions corrected by the correction widths αL, αR as determined is set as the leading vehicle recognition area WP.

[0035] On the other hand, in cases in which the judgment of Step 314 is positive, it is judged that the road is a left-curving road, transition is made to Step 326, and the vehicle speed V of the vehicle 10 is read. In Step 328, the left and right correction values αL', αR' that correspond to the read-out vehicle speed V are determined using the map shown in Figure 12, and in Step 330, the gains GL, GR corresponding to the displacement amount A are determined. That is, because the likelihood that a leading vehicle is present on the left side is high when the road is a left-curving road with a small radius of curvature (large displacement amount A), the correction width αR is decreased by decreasing the right side gain GR using the map shown in Figure 16, and the correction width αL is increased by increasing the left side gain GL using the map shown in Figure 17.

[0036] Next, in Step 332, final left and right correction widths αR, αL of the window area are determined based on the correction values αR', αL' and gains GL, GR as determined, and in Step 334, the leading vehicle recognition area WP is set as the area enclosed by the approximate straight lines 142, 144 with their positions corrected by the left and right correction widths αR, αL as determined. When the leading vehicle recognition area WP has been set as described above, transition is made to Step 336.

[0037] In Step 336, horizontal edge detection processing within the leading vehicle recognition area WP is performed as leading vehicle recognition processing. In horizontal edge detection processing, first, as with edge detection processing in Step 302, detection of the horizontal edge points is performed within the vehicle recognition area WP. Next, the detected horizontal edge points are differentiated in a horizontal direction, and the peak point EP with a derivative that exceeds a predetermined value is detected (see Figure 8(B)). This horizontal edge is highly likely to appear when a leading vehicle is present.

[0038] Next, in Step 338, the positional coordinates of a leading vehicle is computed. First, vertical edge detection processing is performed. When there are multiple peak points E_P of derivatives of the horizontal edge points, the window areas W_R, W_L for detecting vertical lines are set in order from the peak point E_P positioned at the bottom portion of the image so as to include both ends of the horizontal edge points included in the peak points E_P (see Figure 8(C)). The vertical edge is detected within these window areas W_R, W_L, and in cases in which the vertical lines 138R, 138L are stable and are detected, it is judged that a leading vehicle is present in the area sandwiched between the window areas W_R, W_L.

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