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(54) **VEHICLE DRIVING ASSIST DEVICE**

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(57) **ABSTRACT**

A vehicle driving assist device includes an oncoming moving body recognizer configured to recognize an oncoming moving body; a lateral position distribution characteristics acquisition unit configured to acquire distribution characteristics of a lateral position of the oncoming moving body; a risk determination region setting unit configured to set, based on the distribution characteristics, a risk determination region for calculating a risk degree; a risk degree calculator configured to calculate the risk degree for the oncoming moving body; and a preliminary collision avoidance controller configured to recognize the oncoming moving body as the obstacle in accordance with the risk degree, and perform preliminary collision avoidance control in response to the oncoming moving body prior to the emergency collision avoidance control. The risk determination region setting unit is further configured to variably set the risk determination region so that the risk degree relatively increases as the distribution characteristics tend to disperse.

21 Claims, 15 Drawing Sheets
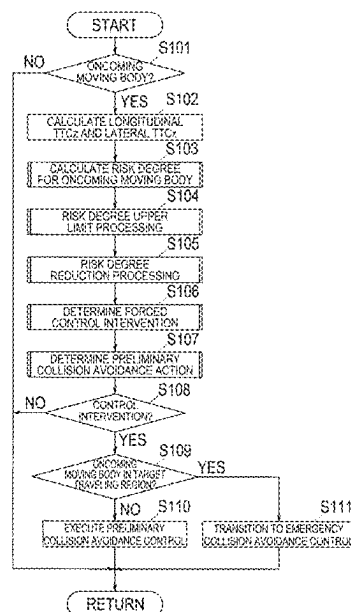
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(58) **Field of Classification Search**
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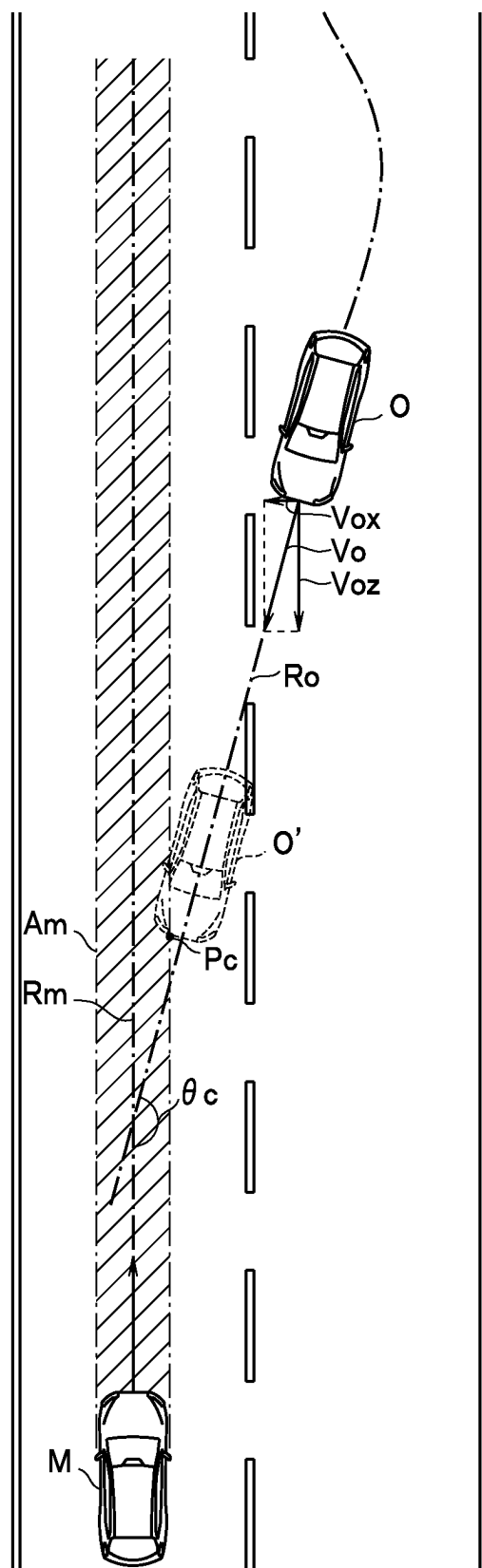|			
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FIG. 1

31 H M I

32 THROTTLE ACTUATOR

33 HYDRAULIC CONTROL CIRCUIT

34 BRAKE ACTUATOR

35 ELECTRIC POWER STEERING MOTOR

21 CP_ECU

22 E/G_ECU

23 T/M_ECU

24 BK_ECU

25 PS_ECU

14 TRAVEL_ECU

13 IMAGE RECOGNITION_ECU

12 IPU

11 {11a 11b}

10

36 {36a GNSS SENSOR 36b ROAD MAP DB}

37lf LEFT FRONT SIDE SENSOR

37rf RIGHT FRONT SIDE SENSOR

37lr LEFT REAR SIDE SENSOR

37rr RIGHT REAR SIDE SENSOR

1

FIG.2

FIG.3

FIG.4

FIG.5

FIG.6

START

S101
ONCOMING
MOVING BODY? — NO

YES
S102
CALCULATE LONGITUDINAL
TTCz AND LATERAL TTCx

S103
CALCULATE RISK DEGREE
FOR ONCOMING MOVING BODY

S104
RISK DEGREE UPPER
LIMIT PROCESSING

S105
RISK DEGREE
REDUCTION PROCESSING

S106
DETERMINE FORCED
CONTROL INTERVENTION

S107
DETERMINE PRELIMINARY
COLLISION AVOIDANCE ACTION

S108
CONTROL
INTERVENTION? — NO

YES
S109
ONCOMING
MOVING BODY IN TARGET
TRAVELING REGION? — YES

NO

S110
EXECUTE PRELIMINARY
COLLISION AVOIDANCE CONTROL

S111
TRANSITION TO EMERGENCY
COLLISION AVOIDANCE CONTROL

RETURN

FIG. 7

START

S201

RECOGNIZE ONCOMING MOVING BODY
FRONT WHEEL(S)

S202

DETERMINE CENTER OF ONCOMING
MOVING BODY

S203

UPDATE HISTOGRAM OF LATERAL POSITION

S204

CALCULATE DISTRIBUTION WIDTH OF
LATERAL POSITION

S205

ACQUIRE TARGET TRAVELING
PATH OF VEHICLE

S206

SET ONCOMING MOVING BODY
RISK DETERMINATION REGION

S207

CALCULATE RISK DEGREE R OF
ONCOMING MOVING BODY

RETURN

FIG. 8

START

S301

ACQUIRE TARGET TRAVELING
PATH OF VEHICLE

S302

CALCULATE PREDICTED TRAVELING
PATH OF ONCOMING MOVING BODY

S303

CALCULATE PREDICTED COLLISION
POINT AND COLLISION ANGLE

S304

BLINKER OF
ONCOMING MOVING BODY
BLINKING? — YES

NO

S305

BEHAVIOR OF
ONCOMING MOVING BODY CHANGED TO
ADVANTAGEOUS? — YES

NO

S306

PARKED
VEHICLE OR THE LIKE IN
ONCOMING LANE? — YES

NO

S307

ONCOMING
MOVING BODY MERGING FROM
BRANCH ROAD? — YES

NO

S308

UPPER LIMIT PROCESSING
FOR SETTING RISK DEGREE
R = 4 AS UPPER LIMIT

RETURN

FIG. 9

START

S401
TTCz<Tth4 ?

YES

NO

S402
PERMIT RISK DEGREE UP TO R = 2
SET RISK LEVEL LV = 1

S403
TTCz<Tth5 ?

YES

NO

S404
PERMIT RISK DEGREE UP TO R = 4
SET RISK LEVEL LV = 2

S405
PERMIT RISK DEGREE UP TO R = 9
SET RISK LEVEL LV = 3

RETURN

FIG. 10

START

S501

ONCOMING
MOVING BODY DIRECTED AT
VEHICLE?

NO

YES   S502
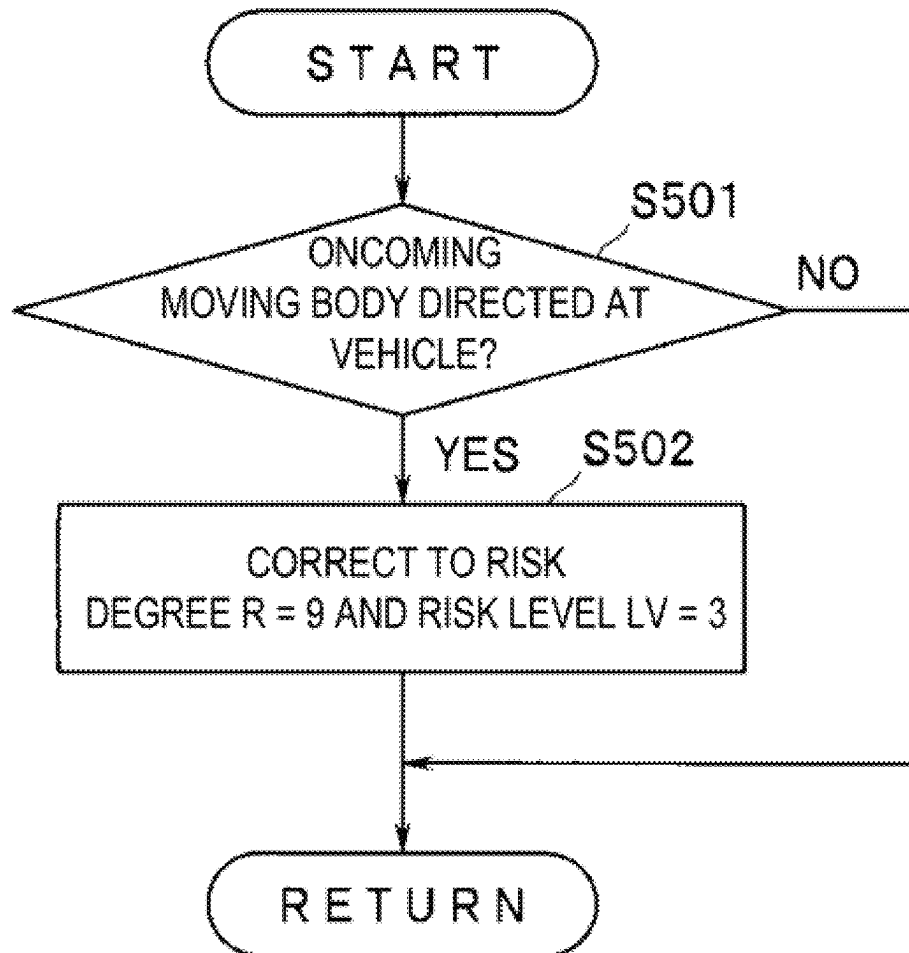
CORRECT TO RISK
DEGREE R = 9 AND RISK LEVEL LV = 3

RETURN

FIG. 11

FIG.12

FIG.13

FIG.14

RISK LEVEL (RISK DEGREE)	NOTIFICATION	LONGITUDINAL AVOIDANCE	LATERAL AVOIDANCE	STEERING WHEEL STEERING SPEED
LV = 3 (4 < R)	Y	PRIMARY DECELERATION BRAKING (0.4 G)	AVOID BY CROSSING LANE	FAST (EXAMPLE: 240 DEG/S)
LV = 2 (2 < R)	Y	SUPPRESS ACCELERATION (DECELERATE BY ACCELERATOR PEDAL RELEASE)	AVOID BY STRADDLING LANES	INTERMEDIATE (EXAMPLE: 80 DEG/S)
LV = 1 (0 < R)	N	SUPPRESS ACCELERATION (LIMIT ACCELERATION SUPPRESSION)	AVOID BY BEING IN SAME LANE	SLOW (EXAMPLE: 10 DEG/S)
LV = 0 (R = 0)	N	—	—	—

FIG. 15

VEHICLE DRIVING ASSIST DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from Japanese Patent Application No. 2022-008968 filed on Jan. 24, 2022, the entire contents of which are hereby incorporated by reference.

BACKGROUND

The disclosure relates to a vehicle driving assist device having a function of performing collision avoidance control in response to an obstacle.

In vehicles such as an automobile, driving assist devices for assisting driving operations of a driver have been put to practical use for the purpose of alleviating a burden of the driving operations of the driver and achieving improvements in safety. With this type of driving assist device, various driving modes are set. These driving modes include, for example, a manual driving mode for performing steering and acceleration/deceleration in accordance with independent driving operations by the driver, a driving assist mode for performing steering assist control and acceleration/deceleration control on the premise of independent driving operations by the driver, and a driving assist mode for causing a vehicle to travel without using any driving operations by the driver (so-called automatic driving mode).

The driving assist control in each of the driving assist modes is basically realized by providing an adaptive cruise control (ACC) function and an active lane keep centering (ALKC) control function, and the like. With such driving assist control, the vehicle can be caused to travel along a traveling lane while maintaining an inter-vehicle distance from a preceding vehicle.

Further, as a technique related to active safety of the driving assist device, various proposals have been made for performing collision avoidance control with an obstacle present on a traveling path ahead of the host vehicle (refer to, for example, Japanese Unexamined Patent Application Publication (JP-A) No. 2016-224501). In the technique of JP-A No. 2016-224501, a collision predictor identifies an expected collision region with an obstacle from a traveling trajectory (target traveling path) of the host vehicle and a position, a shape, a movement direction, and the like of the obstacle. Further, the collision predictor integrates a collision probability value of collision with the obstacle in an expected collision region. Then, in a case where an integrated value of the collision probability value becomes large in one or more expected collision regions identified at points in time, a collision determination unit generates an alert signal.

SUMMARY

An aspect of the disclosure provides a vehicle driving assist device. The vehicle driving assist device includes a traveling environment recognizer, an obstacle recognizer, an emergency collision avoidance controller, an oncoming moving body recognizer, a lateral position distribution characteristics acquisition unit, a risk determination region setting unit, a risk degree calculator, and a preliminary collision avoidance controller. The traveling environment recognizer is configured to recognize traveling environment information about a traveling environment outside a vehicle. The obstacle recognizer is configured to recognize, based on the

traveling environment information, an obstacle present on a target traveling path of the vehicle. The emergency collision avoidance controller is configured to perform, upon determination that the vehicle is highly likely to collide with the obstacle, emergency collision avoidance control for avoiding collision of the vehicle with the obstacle. The oncoming moving body recognizer is configured to recognize, based on the traveling environment information, an oncoming moving body moving in an oncoming lane adjacent to a traveling lane of the vehicle and having a velocity component in a direction opposite to a traveling direction of the vehicle. The lateral position distribution characteristics acquisition unit is configured to acquire distribution characteristics of a lateral position of the oncoming moving body in association with movement of the oncoming moving body. The risk determination region setting unit is configured to set, based on the distribution characteristics of the lateral position, a risk determination region for calculating a risk degree that decreases as a distance outward from a center of the oncoming lane in a width direction of a road increases. The risk degree calculator is configured to calculate the risk degree for the oncoming moving body in accordance with an overlap state between the target traveling path of the vehicle and the risk determination region. The preliminary collision avoidance controller is configured to recognize the oncoming moving body as the obstacle in accordance with the risk degree, and perform preliminary collision avoidance control in response to the oncoming moving body recognized as the obstacle prior to the emergency collision avoidance control. The risk determination region setting unit is further configured to variably set the risk determination region so that the risk degree calculated relatively increases as the distribution characteristics tend to disperse.

An aspect of the disclosure provides a vehicle driving assist device. The vehicle driving assist device includes a traveling environment recognizer, and circuitry. The traveling environment recognizer includes a sensor and is configured to recognize traveling environment information about a traveling environment outside a vehicle. The circuitry is configured to recognize, based on the traveling environment information, an obstacle present on a target traveling path of the vehicle. The circuitry is configured to, upon determination that the vehicle is highly likely to collide with the obstacle, perform emergency collision avoidance control for avoiding collision with the obstacle. The circuitry is configured to recognize, based on the traveling environment information, an oncoming moving body moving in an oncoming lane adjacent to a traveling lane of the vehicle and having a velocity component in a direction opposite to a traveling direction of the vehicle. The circuitry is configured to acquire distribution characteristics of a lateral position of the oncoming moving body in association with movement of the oncoming moving body. The circuitry is configured to set, based on the acquired distribution characteristics of the lateral position, a risk determination region for calculating a risk degree that decreases as a distance outward from a center of the oncoming lane in a width direction of a road increases. The circuitry is configured to calculate the risk degree for the oncoming moving body in accordance with an overlap state between the target traveling path of the vehicle and the risk determination region; recognize the oncoming moving body as the obstacle in accordance with the risk degree, and perform preliminary collision avoidance control in response to the oncoming moving body recognized as the obstacle prior to the emergency collision avoidance control. The circuitry is configured to set the risk determination

region so that the risk degree calculated relatively increases as the distribution characteristics of the lateral position tend to disperse.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of this specification. The drawings illustrate an example embodiment and, together with the specification, serve to describe the principles of the disclosure.

FIG. 1 is a schematic configuration diagram of a driving assist device.

FIG. 2 is an explanatory view illustrating a monitoring region of a stereo camera and radar.

FIG. 3 is an explanatory view illustrating an obstacle present on a target traveling path ahead of the host vehicle.

FIG. 4 is an explanatory view illustrating an oncoming moving body present in an oncoming lane.

FIG. 5 is an explanatory view illustrating a trajectory of a representative point of the oncoming moving body.

FIG. 6 is an explanatory view illustrating a relationship between a target traveling path of the host vehicle and the risk determination region of the oncoming moving body.

FIG. 7 is a flowchart illustrating a preliminary collision avoidance control routine.

FIG. 8 is a flowchart illustrating a risk degree calculation subroutine.

FIG. 9 is a flowchart illustrating a risk degree upper limit processing subroutine.

FIG. 10 is a flowchart illustrating a risk degree reduction processing subroutine.

FIG. 11 is a flowchart illustrating a forced control intervention determination subroutine.

FIG. 12 is an explanatory view illustrating a case where the risk degree of the oncoming moving body increases due to a factor other than wandering.

FIG. 13 is an explanatory view illustrating a case where the risk degree of the oncoming moving body increases due to a factor other than wandering.

FIG. 14 is an explanatory view illustrating a case where a risk degree of the oncoming moving body increases due to a factor other than wandering.

FIG. 15 is an explanatory view illustrating control contents of preliminary collision avoidance control.

DETAILED DESCRIPTION

An oncoming vehicle or the like traveling in an oncoming lane adjacent to a host vehicle traveling lane is basically present at a position separated in a vehicle width direction from a target traveling path of the host vehicle. Accordingly, the oncoming vehicle or the like may not be an applicable target of collision avoidance control. In this case, for example, in a case where the oncoming vehicle or the like suddenly enters the traveling lane of the host vehicle due to the inattentiveness or the like of the driver driving the oncoming vehicle or the like, it may be difficult to realize sufficient collision avoidance control in response to the oncoming vehicle.

It is desirable to provide a vehicle driving assist device that can ensure sufficient safety even in a case where an oncoming vehicle or the like suddenly enters a traveling lane of a host vehicle.

In the following, an embodiment of the disclosure is described in detail with reference to the accompanying

drawings. Note that the following description is directed to an illustrative example of the disclosure and not to be construed as limiting to the disclosure. Factors including, without limitation, numerical values, shapes, materials, components, positions of the components, quantities of the components, and how the components are coupled to each other are illustrative only and not to be construed as limiting to the disclosure. Further, elements in the following example embodiment which are not recited in a most-generic independent claim of the disclosure are optional and may be provided on an as-needed basis. The drawings are schematic and are not intended to be drawn to scale. Throughout the present specification and the drawings, elements having substantially the same function and configuration are denoted with the same numerals to avoid any redundant description. As illustrated in FIGS. 1 and 2, a driving assist device 1 includes a camera unit 10 fixed to an upper center of a front part in a cabin of a vehicle (host vehicle) M, for example.

This camera unit 10 includes a stereo camera 11, an image processing unit (IPU) 12, an image recognition unit (image recognition_ECU) 13, and a traveling control unit (travel_ECU) 14.

The stereo camera 11 includes a main camera 11a and a sub-camera 11b. The main camera 11a and the sub-camera 11b are each constituted by a complementary metal-oxide semiconductor (CMOS), for example.

The main camera 11a and the sub-camera 11b are disposed in left-right symmetric positions across a center in a vehicle width direction.

The main camera 11a and the sub-camera 11b capture stereo images of a traveling environment in a region Af (refer to FIG. 2) in front and outside of the host vehicle from different viewpoints. Image capturing cycles of the main camera 11a and sub-camera 11b are synchronized with each other.

The IPU 12 performs predetermined image processing on traveling environment images captured by the stereo camera 11. The IPU 12 thus detects edges of various objects represented in the images, such as solid objects or lane markers on a road surface. Then, the IPU 12 finds distance information from a position deviation amount of the corresponding edges in the left and right images. In this way, the IPU 12 generates image information (distance image information) including distance information.

On the basis of the distance image information and the like received from the IPU 12, the image recognition_ECU 13 determines the road curvature (1/m) of the lane markers defining the left and right sides of the lane in which the host vehicle M is traveling (host vehicle traveling path), and the width between the left and right lane markers (lane width). Further, the image recognition_ECU 13 determines the road curvature of the lane markers defining the left and right sides of a lane or the like adjacent to the lane in which the host vehicle M is traveling, and the width between the left and right lane markers. Various methods of determining the curvatures and the lane widths are known. For example, the image recognition_ECU 13 performs binarization processing based on luminance for each pixel on a distance image. As a result, the image recognition_ECU 13 extracts lane marker candidate points on the road. Further, the image recognition_ECU 13 performs curve approximation by the least-squares method on a string of the extracted lane marker candidate points.

The image recognition_ECU 13 thus determines the curvatures of the left and right lane markers for each predetermined section. Furthermore, the image recognition_ECU 13

calculates the lane width from the difference between the curvatures of both the left and right lane markers.

Then, the image recognition_ECU **13** calculates a lane center, a lateral position deviation of the host vehicle, and the like on the basis of the curvatures of the left and right lane markers and the lane width. Herein, the lateral position deviation of the host vehicle is a distance from the lane center to the center of the host vehicle M in the vehicle width direction.

Further, the image recognition_ECU **13** performs predetermined pattern matching or the like on the distance image information. The image recognition_ECU **13** thus recognizes solid objects, such as a guardrail, a curb, a median strip, and nearby vehicles present along the road. Herein, upon recognizing the solid object, the image recognition-_ECU **13** recognizes, for example, a type of the solid object, a distance to the solid object, a velocity of the solid object, and a relative velocity between the solid object and the host vehicle M.

Each of the various types of information recognized in the image recognition_ECU **13** is output to a travel_ECU **14** as traveling environment information.

As described, the image recognition_ECU **13** recognizes the traveling environment information outside the vehicle. In one embodiment, along with the stereo camera **11** and the IPU **12**, the image recognition_ECU **13** may serve as a "traveling environment recognizer".

The travel_ECU **14** is a control unit for comprehensively controlling the driving assist device **1**.

This travel_ECU **14** is coupled, via an in-vehicle communication line such as a controller area network (CAN), to various control units. The various control units include a cockpit control unit (CP_ECU) **21**, an engine control unit (E/G_ECU) **22**, a transmission control unit (T/M_ECU) **23**, a braking control unit (BK_ECU) **24**, and a power steering control unit (PS_ECU) **25**.

Furthermore, the travel_ECU **14** is coupled to various types of sensors including a locator unit **36**, a left front side sensor **37**lf, a right front side sensor **37**rf, a left rear side sensor **37**lr, and a right rear side sensor **37**rr.

The CP_ECU **21** is coupled to a human machine interface (HMI) **31** disposed around the driver's seat. The HMI **31** includes, for example, operation switches for setting and executing various types of driving assist controls and the like, a mode switch for switching the driving assist mode, a steering touch sensor that detects a steering state of the driver, a turn signal switch, a driver monitoring system (DMS) that performs facial recognition, eye detection, or the like of the driver, a touch panel type display, a combination meter, and a speaker.

The CP_ECU **21**, upon receiving a control signal from the travel_ECU **14**, notifies the driver, as appropriate, of various types of alerts related to a preceding vehicle or the like, an implementation state of the driving assist control, and various information related to the traveling environment and the like of the host vehicle M, by display, audio, or the like through the HMI **31**.

Further, the CP_ECU **21** outputs various input information to the travel_ECU **14**, such as an on or off operation state of each of the various driving assist controls input by the driver through the HMI **31**, a vehicle velocity Vs set for the host vehicle M (set vehicle velocity), and an operation state of a turn signal switch.

The E/G_ECU **22** is coupled, at its output side, to a throttle actuator **32** of an electronic control throttle or the

like. Further, the E/G_ECU **22** is coupled, at its input side, to various sensors such as an accelerator sensor (not illustrated).

The E/G_ECU **22** controls the driving of the throttle actuator **32** on the basis of control signals from the travel_ECU **14**, detection signals from various sensors, or the like. This causes the E/G_ECU **22** to adjust an amount of intake air of the engine and generate a desired engine output. Further, the E/G_ECU **22** outputs signals of an accelerator pedal position and the like detected by the various sensors to the travel_ECU **14**.

The T/M_ECU **23** is coupled, at its output side, to a hydraulic control circuit **33**. Further, the T/M_ECU **23** is coupled, at its input side, to various sensors such as a shift position sensor (not illustrated). The T/M_ECU **23** performs hydraulic control for the hydraulic control circuit **33** on the basis of an engine torque signal estimated by the E/G_ECU **22**, detection signals from various sensors, and the like. Thus, the T/M_ECU **23** operates frictional engagement elements, pulleys, and the like provided in an automatic transmission, and causes the engine output to shift at a desired transmission ratio. Further, the T/M_ECU **23** outputs signals of a shift position and the like detected by various sensors to the travel_ECU **14**.

The BK_ECU **24** is coupled, at its output side, to a brake actuator **34**. The brake actuator **34** adjusts the brake fluid pressure to be fed to brake wheel cylinders provided for respective wheels. Further, the BK_ECU **24** is coupled, at its input side, to various sensors such as a brake pedal sensor, a yaw rate sensor, front/rear acceleration sensors, and a vehicle speed sensor (not illustrated).

The BK_ECU **24** controls the driving of the brake actuator **34** on the basis of control signals from the travel_ECU **14** or detection signals from various sensors. The BK_ECU **24** thus generates, at each wheel, a braking force for performing forced braking control, yaw rate control, and the like on the host vehicle M, as appropriate. Further, the BK_ECU **24** outputs signals of a brake operation state, a yaw rate, a forward/reverse acceleration, a vehicle velocity (host vehicle velocity), and the like detected by various sensors to the travel_ECU **14**.

The PS_ECU **25** is coupled, at its output side, to an electric power steering motor **35**. The electric power steering motor **35** applies a steering torque to a steering mechanism by a rotational force of the motor. Further, the PS_ECU **25** is coupled, at its input side, to various sensors such as a steering torque sensor and a steering angle sensor.

The PS_ECU **25** controls the driving of the electric power steering motor **35** on the basis of control signals from the travel_ECU **14** or detection signals from various sensors. As a result, the PS_ECU **25** generates a steering torque for the steering mechanism. Further, the PS_ECU **25** outputs signals of the steering torque, a steering angle, and the like detected by various sensors to the travel_ECU **14**.

The locator unit **36** includes a global navigation satellite system (GNSS) sensor **36**a and a high-precision road map database (road map DB) **36**b.

The GNSS sensor **36**a receives positioning signals transmitted from positioning satellites, and thus measures a position (latitude, longitude, altitude, and the like) of the host vehicle M.

The road map DB **36**b is a large-capacity storage medium such as a hard disk drive (HDD). This road map DB **36**b stores high-precision road map information (a dynamic map). The road map information includes, for example, lane width data, lane center position coordinate data, azimuth angle data of the lane, and speed limit data, as lane data

when performing automatic driving. The lane data is stored for each lane on the road map at an interval of several meters. On the basis of a request signal from the travel_ECU 14, the road map DB 36*b* outputs to the travel_ECU 14, as the traveling environment information, road map information of a set range based on the host vehicle position measured by the GNSS sensor 36*a*, for example.

As described, the road map DB 36*b* recognizes the traveling environment information outside the vehicle. In one embodiment, along with the GNSS sensor 36*a*, the road map DB 36*b* may serves a "traveling environment recognizer".

The left front side sensor 37*lf* and the right front side sensor 37*rf* are each constituted by, for example, a millimeter wave radar. The left front side sensor 37*lf* and the right front side sensor 37*rf* are disposed respectively on the left and right sides of a front bumper, for example. The left front side sensor 37*lf* and the right front side sensor 37*rf* detect, as the traveling environment information, solid objects present in regions Alf, Arf (refer to FIG. 2) that are left and right oblique front and side regions of the host vehicle M and difficult to recognize in images of the stereo camera 11.

The left rear side sensor 37*lr* and the right rear side sensor 37*rr* are each constituted by, for example, a millimeter wave radar. The left rear side sensor 37*lr* and the right rear side sensor 37*rr* are disposed respectively on left and right sides of a rear bumper, for example. The left rear side sensor 37*lr* and the right rear side sensor 37*rr* detect, as the traveling environment information, solid objects present in regions Alr, Arr (refer to FIG. 2) that are left and right oblique rear and side regions of the host vehicle M and difficult to recognize by the left front side sensor 37*lf* and the right front side sensor 37*rf*.

Herein, in a case where each sensor is constituted by a millimeter wave radar, the millimeter wave radar detects mainly a solid object such as a parallel traveling vehicle, a following vehicle, or the like by analyzing reflected waves reflected by an object with respect to the electric waves output from the millimeter wave radar. In one example, each radar detects, as information related to the solid object, the lateral width of the solid object, the position of a representative point of the solid object (relative position with respect to the host vehicle M), the velocity of the solid object, and the like.

As described, the left front side sensor 37*lf*, the right front side sensor 37*rf*, the left rear side sensor 37*lr*, and the right rear side sensor 37*rr* recognize the traveling environment information outside the vehicle. In one embodiment, the left front side sensor 37*lf*, the right front side sensor 37*rf*, the left rear side sensor 37*lr*, and the right rear side sensor 37*rr* may serve as a "traveling environment recognizer".

Note that coordinates of each target outside the vehicle included in the traveling environment information recognized by the image recognition_ECU 13, the locator unit 36, the left front side sensor 37*lf*, the right front side sensor 37*rf*, the left rear side sensor 37*lr*, and the right rear side sensor 37*rr* are converted to coordinates of a three-dimensional coordinate system (refer to FIG. 2) in which the center of the host vehicle M is set as the origin, for example, in the travel_ECU 14.

The driving modes set in the travel_ECU 14 include a manual driving mode, a first travel control mode and a second travel control mode as modes for travel control, and a safe stop mode. These driving modes are each selectively switchable in the travel_ECU 14 on the basis of, for example, the operation status of the mode switch provided to the HMI 31, for example.

Herein, the manual driving mode is a driving mode in which the driver holds the steering wheel. That is, the manual driving mode is a driving mode in which the driver causes the host vehicle M to travel in accordance with driving operations such as a steering operation, an acceleration operation, and a braking operation, for example.

Similarly, the first travel control mode is a driving mode in which the driver holds the steering wheel.

That is, the first travel control mode is a so-called semi-automated driving mode in which the host vehicle M is caused to travel while reflecting the driving operations by the driver. This first travel control mode is realized by, for example, the travel_ECU 14 outputting various control signals to the E/G_ECU 22, the BK_ECU 24, and the PS_ECU 25. In the first travel control mode, mainly adaptive cruise control (ACC), active lane keep centering (ALKC) control, active lane keep bouncing (ALKB) control, lane change control, and the like are performed in combination as appropriate. This makes it possible for the host vehicle M to travel along the target traveling path. Furthermore, in the first travel control mode, the lane change control can be performed when the turn signal switch is operated by the driver.

Herein, the adaptive cruise control is basically performed on the basis of the traveling environment information input from the image recognition_ECU 13 or the like.

In one example, in a case where a preceding vehicle is recognized ahead of the host vehicle M by the image recognition_ECU 13 or the like, the travel_ECU 14 performs adaptive travel control as a part of the adaptive cruise control. In this adaptive travel control, the travel_ECU 14 sets a target inter-vehicle distance Lt and a target vehicle velocity Vt on the basis of a vehicle velocity Vl of the preceding vehicle or the like. Then, the travel_ECU 14 performs acceleration/deceleration control for the host vehicle M on the basis of the target inter-vehicle distance Lt and the target vehicle velocity Vt. In this way, the travel_ECU 14 basically causes the host vehicle M to travel following the preceding vehicle in a state of maintaining a vehicle velocity V at the target vehicle velocity Vt while maintaining an inter-vehicle distance L at the target inter-vehicle distance Lt.

On the other hand, for example, in a case where no preceding vehicle is recognized ahead of the host vehicle M by the image recognition_ECU 13 or the like, the travel_ECU 14 performs constant velocity travel control as a part of the adaptive cruise control. In this constant velocity travel control, the travel_ECU 14 sets the set vehicle velocity Vs input by the driver as the target vehicle velocity Vt. Then, the travel_ECU 14 performs acceleration/deceleration control for the host vehicle M on the basis of the target vehicle velocity Vt. In this way, the travel_ECU 14 maintains the vehicle velocity V of the host vehicle M at the set vehicle velocity Vs.

Further, the active lane keep centering control and the active lane keep bouncing control are basically performed on the basis of the traveling environment information input from at least one of the image recognition_ECU 13 or the locator unit 36. That is, the travel_ECU 14 sets a target traveling path Rm at the center of the host vehicle traveling lane along the left and right lane markers on the basis of, for example, the lane marker information or the like included in the traveling environment information. Then, the travel_ECU 14 keeps the host vehicle M in the center of the lane by performing feed-forward control, feed-back control, and the like for steering on the basis of the target traveling path Rm. Further, upon determination that the host vehicle M is

likely to deviate from the host vehicle traveling lane due to the influence of a lateral wind, a cant of the road, or the like, the travel_ECU **14** suppresses the lane deviation by forced steering control.

Further, lane change control is basically performed on the basis of the traveling environment information input from the image recognition_ECU **13**, the left front side sensor **37***lf*, the right front side sensor **37***rf*, the left rear side sensor **37***lr*, and the right rear side sensor **37***rr*. This lane change control is executed when, for example, the turn signal switch is operated by the driver. That is, the travel_ECU **14** recognizes an adjacent lane present in the operation direction of the turn signal switch on the basis of the traveling environment information. Further, the travel_ECU **14** recognizes whether a vehicle or the like that inhibits a lane change is present in the adjacent lane. Then, the travel_ECU **14**, upon determination that space exists for a lane change in the adjacent lane, performs the lane change to the adjacent lane. This lane change control is performed in coordination with the adaptive cruise control.

The second travel control mode is a driving mode in which the host vehicle M is caused to travel without driving operation by the driver, that is, without holding the steering wheel or performing an acceleration operation or a braking operation. That is, the second travel control mode is a so-called automatic driving mode in which the host vehicle M is caused to travel autonomously without driving operation by the driver. This second travel control mode is realized by, for example, the travel_ECU **14** outputting various control signals to the E/G_ECU **22**, the BK_ECU **24**, and the PS_ECU **25**. In the second travel control mode, mainly preceding-vehicle adaptive control, active lane keep centering control, active lane keep bouncing control, and the like are performed in combination as appropriate.

This makes it possible for the host vehicle M to travel along the target route (route map information). Furthermore, in the second travel control mode, lane change control can also be performed. Note that, in the second travel control mode, lane change control is performed automatically, as appropriate, not only when the turn signal switch is operated by the driver, but also in accordance with a travel route up to a destination set in the host vehicle M, traveling environment information, and the like.

The safe stop mode is a mode for automatically stopping the host vehicle M at a side strip or the like. This safe stop mode is executed, for example, in a case where the traveling based on the second travel control mode becomes uncontinuable during the traveling in the second travel control mode, and the driver fails to take over the driving operation, for example (that is, where the second travel control mode cannot transition to the manual driving mode or to the first travel control mode).

Further, in each of the driving modes described above, the travel_ECU **14** performs emergency collision avoidance control, as appropriate, for an obstacle such as a vehicle that is highly likely to collide with the host vehicle M. This emergency collision avoidance control includes, for example, emergency braking (autonomous emergency braking (AEB)) control and emergency steering control.

The emergency braking control is basically control for avoiding a collision with an obstacle present in the target traveling path Rm ahead of the host vehicle M by braking. In the emergency braking control, the travel_ECU **14** sets, for example, a target traveling region Am ahead of the host vehicle M, as illustrated in FIG. **3**. This target traveling region Am includes a predetermined width (greater than or equal to the vehicle width of the host vehicle M, for example) centered on the target traveling path Rm. Further, the travel_ECU **14** detects an obstacle such as a preceding vehicle or a parked vehicle present in the target traveling region Am on the basis of the traveling environment information. Furthermore, the travel_ECU **14** calculates, as a predicted collision time with the obstacle, a time-to-collision (longitudinal time-to-collision) TTCz in a front-rear direction of the host vehicle M. This longitudinal time-to-collision TTCz is calculated on the basis of a relative velocity and a relative distance between the host vehicle M and the obstacle.

Then, the travel_ECU **14** executes primary braking control when the longitudinal time-to-collision TTCz becomes less than a first threshold value Tth**1** set in advance. When the primary braking control is started, the travel_ECU **14** decelerates the host vehicle M by using a first target deceleration a**1** (0.4 G, for example) set in advance.

Further, the travel_ECU **14** executes secondary braking control when the longitudinal time-to-collision TTCz is less than a second threshold value Tth**2** (where Tth**2**<Tth**1**) set in advance. When secondary braking control is started, the travel_ECU **14** decelerates the host vehicle M until the relative velocity relative to the obstacle is "0" by using a second target deceleration a**2** (1 G, for example) set in advance.

Emergency steering control is control for avoiding a collision with an obstacle present in the target traveling path ahead of the host vehicle M by steering. Upon determination that collision with the obstacle cannot be avoided by, for example, secondary braking control, the travel_ECU **14** executes emergency steering control instead of or in conjunction with emergency braking control.

In one example, the travel_ECU **14** executes emergency steering control (refer to a host vehicle M' in FIG. **3**, for example) when the longitudinal time-to-collision TTCz is less than a third threshold value Tth**3** (where Tth**3**<Tth**2**) set in advance.

In this emergency steering control, the travel_ECU **14** sets a target lateral position to the side of the obstacle. Further, the travel_ECU **14** sets a new target traveling path Ravo for causing the host vehicle M to reach the target lateral position. This new target traveling path Ravo is set by, for example, creating two sections: a steering away section for causing the host vehicle M to head toward the side of the obstacle, and a steering back section for returning an orientation of the host vehicle M to a direction along the host vehicle traveling path. Then, the travel_ECU **14** executes steering control along the new target traveling path Ravo.

Note that the travel_ECU **14** may variably set each of the first to third threshold values Tth**1** to Tth**3** in accordance with an overlap ratio of the obstacle to the host vehicle M in the vehicle width direction. This overlap ratio Rr is calculated, for example, on the basis of an amount by which the obstacle enters the target traveling region Am. Then, the travel_ECU **14** sets each threshold value so that the first to third threshold values Tth**1** to Tth**3** increase as the overlap ratio Rr increases by using a map or the like set in advance, for example.

However, when the host vehicle M is traveling on a road in which a median strip is not present, a case is expected where an oncoming moving body O present in the oncoming lane suddenly enters the traveling lane of the host vehicle M. Here, in the present embodiment, the oncoming moving body O refers to an oncoming vehicle (including a two-wheeled vehicle), a pedestrian, or the like that moves with a velocity component in a direction opposite to the movement direction of the host vehicle M. To realize collision

avoidance with such an oncoming moving body O, the travel_ECU **14** of the present embodiment extends and applies emergency collision avoidance control in response to the oncoming moving body O entering the traveling lane of the host vehicle M from the oncoming lane of the road without the median strip.

Prior to the emergency collision avoidance control targeting the oncoming moving body O, the travel_ECU **14** performs, as appropriate, preliminary collision avoidance control, as necessary. This preliminary collision avoidance control is control for suppressing a risk of collision of the host vehicle M with the oncoming moving body O in advance.

To execute the preliminary collision avoidance control, the travel_ECU **14** determines, on the basis of the traveling environment information, whether a median strip that divides the road into the traveling lane of the host vehicle M and the oncoming lane is present on the road. Then, in a case where a median strip is not present on the road traveled by the host vehicle M, the travel_ECU **14** detects the oncoming moving body O moving in the oncoming lane, for example (refer to FIG. **4**). Upon detection of the oncoming moving body O, the travel_ECU **14** calculates, on the basis of a velocity Vo of the oncoming moving body O, a longitudinal velocity component Voz and a lateral velocity component Vox corresponding to the front-rear direction and the vehicle width direction of the host vehicle M.

Further, the travel_ECU **14** calculates, as predicted collision times for the oncoming moving body O, the time-to-collision (longitudinal time-to-collision) TTCz in the front-rear direction of the host vehicle M and a time-to-collision (lateral time-to-collision) TTCx in the vehicle width direction of the host vehicle M.

That is, for example, the travel_ECU **14** calculates the longitudinal time-to-collision TTCz by dividing a relative velocity in the longitudinal direction calculated from the vehicle velocity V of the host vehicle M and the longitudinal velocity component Voz of the oncoming moving body O by a relative distance between the host vehicle M and the oncoming moving body O in the longitudinal direction.

Further, the travel_ECU **14** calculates the lateral time-to-collision TTCx by, for example, dividing the lateral velocity component Vox of the oncoming moving body O by a distance from the oncoming moving body O to the target traveling region Am. In the calculation of this lateral time-to-collision TTCx, in some embodiments, the distance from the oncoming moving body O to the target traveling region Am is corrected on the basis of a width of the oncoming moving body O and an entry angle (predicted collision angle) of the oncoming moving body O with respect to the target traveling region Am.

Furthermore, the travel_ECU **14** calculates a risk degree R as a parameter indicating a likelihood (risk) of the oncoming moving body O colliding with the host vehicle M.

In calculating this risk degree R, the travel_ECU **14** sets a risk determination region. This risk determination region is configured to extend in a width direction of the road from the center of the oncoming lane, for example. The risk determination region is a region for calculating the risk degree R that differs in value depending on a distance outward from the center of the oncoming moving body O in the width direction of the oncoming moving body O, as illustrated in FIG. **6**, for example. For example, in the risk determination region illustrated in FIG. **6**, four small regions including a "danger region", a "warning region", a "caution region", and a "safe region" are set in this order from the center of the oncoming lane.

Then, in each of the small regions, the risk degrees R of "9", "4", "2", and "0" are set with the risk degree R decreasing stepwise as the distance from the oncoming moving body O increases.

The widths of the danger region, warning region, caution region, and safe region are variably set in accordance with a wandering state of the oncoming moving body O. The width of each of these small regions is set on the basis of statistical results of whether the oncoming moving body O has a wandering tendency.

In one embodiment, the travel_ECU **14** sets a lateral position x of the oncoming moving body O relative to the host vehicle M when the oncoming moving body O is first detected as a reference lateral position x0 (refer to FIG. **5**). Further, the travel_ECU **14** calculates a change amount Δx of the lateral position x of the oncoming moving body O with respect to the reference lateral position x0 every set cycle. Then, the travel_ECU **14** acquires distribution characteristics of the lateral position of the oncoming moving body O using the change amount Δx of the lateral position x calculated every set cycle.

The distribution characteristics of this lateral position are generated by, for example, aggregating, as a class, the change amount Δx of the lateral position x of the oncoming moving body O with respect to the reference lateral position x0, for every predetermined change amount Δx, and creating a histogram (refer to FIG. **6**). The distribution characteristics of this lateral position x generally reveal a normal distribution. The normal distribution of the distribution characteristics of the lateral position x disperses (a distribution width Wx widens) as the oncoming moving body O increasingly wanders, and converges (the distribution width Wx narrows) as the oncoming moving body O decreasingly wanders.

On the basis of such distribution characteristics of the lateral position x, the travel_ECU **14** variably sets the width of each of small region with reference to a map or the like set in advance. In one embodiment, the travel_ECU **14** sets each small region so that, as the distribution width Wx of the lateral position x widens (that is, the more the distribution characteristics of the lateral position x tend toward dispersion), the small region on the danger side expands in a road width direction and the small region on the safe side recedes in the road width direction. Note that, for example, as illustrated in FIG. **6**, when the small region on the danger side expands, the small region on the safe side progressively disappears.

For example, in the example illustrated in FIGS. **5** and **6**, the oncoming moving body O moves while largely wandering.

Accordingly, as the oncoming moving body O approaches the host vehicle M, the distribution characteristics of the lateral position x tend toward dispersion. As a result, the small region on the danger side in the risk determination region gradually expands.

Here, the width of each small region can be variably set on the basis of, for example, a known sample distribution S2, instead of the distribution width Wx.

Upon setting the risk determination region, the travel_ECU **14** calculates the risk degree R for the oncoming moving body O in accordance with an overlap state of the target traveling path Rm of the host vehicle M and the risk determination region. That is, the travel_ECU **14** sets the risk degree R of the small region penetrated by the target traveling path Rm as the risk degree R for the current oncoming moving body O. As understood from FIG. **6** as well, the risk degree R increases as the oncoming moving body O moves toward the traveling lane of the host vehicle

M due to wandering of the oncoming moving body O or the like. Factors that may cause the oncoming moving body O to wander include, for example, the driver driving the oncoming moving body O falling asleep, looking aside, or executing a wrong operation.

On the basis of the risk degree R thus calculated, the travel_ECU **14** determines whether the oncoming moving body O is an obstacle that may collide with the host vehicle M. Then, upon recognizing the oncoming moving body O as an obstacle, the travel_ECU **14** executes, as appropriate, preliminary collision avoidance control prior to emergency collision avoidance control in response to the oncoming moving body O.

In one embodiment, the travel_ECU **14** may serve an "obstacle recognizer", "an emergency collision avoidance controller", an "oncoming moving body recognizer", a "lateral position distribution characteristics acquisition unit", a "risk determination region setting unit", a "risk degree calculator", and a "preliminary collision avoidance controller".

Details of the preliminary collision avoidance control will now be described following the flowchart of a preliminary collision avoidance control routine illustrated in FIG. **7**. This preliminary collision avoidance control routine is executed repeatedly for every set time in the travel_ECU **14** when the host vehicle M is traveling on a road without a median strip present.

When the routine starts, the travel_ECU **14**, in step S**101**, checks whether the oncoming moving body O is present in the oncoming lane.

Then, in step S**101**, in a case where the travel_ECU **14** determines that the oncoming moving body O is not present in the oncoming lane (step S**101**: NO), the travel_ECU **14** exits the routine.

On the other hand, in step S**101**, in a case where the travel_ECU **14** determines that the oncoming moving body O is present in the oncoming lane (step S**101**: YES), the travel_ECU **14** proceeds to step S**102**.

In step S**102**, the travel_ECU **14** calculates the longitudinal time-to-collision TTCz and the lateral time-to-collision TTCx for the oncoming moving body O.

In a subsequent step S**103**, the travel_ECU **14** calculates the risk degree R for the oncoming moving body O. The calculation of the risk degree R is performed according to the flowchart of a risk degree calculation subroutine illustrated in FIG. **8**, for example.

When the subroutine starts, the travel_ECU **14**, in step S**201**, recognizes the front wheel(s) of the oncoming moving body O in a case where the oncoming moving body O is a four-wheeled vehicle, a two-wheeled vehicle, or the like.

In a subsequent step S**202**, the travel_ECU **14** determines the center of the oncoming moving body O. That is, for example, in a case where the oncoming moving body O is a four-wheeled vehicle, the travel_ECU **14** determines a center of treads of the front wheels recognized in step S**201** as the center of the oncoming moving body O. Further, for example, in a case where the oncoming moving body O is a two-wheeled vehicle, the travel_ECU **14** determines the position of the front wheel recognized in step S**201** as the center of the oncoming moving body O.

In a subsequent step S**203**, the travel_ECU **14** updates the histogram showing the distribution of the lateral position of the oncoming moving body O. That is, for example, the travel_ECU **14** calculates, for example, the lateral position of the center of the oncoming moving body O currently identified as the lateral position x of the current oncoming moving body O on the road. Further, the travel_ECU **14**

calculates the change amount Δx of the lateral position x with respect to the reference lateral position x0. Then, the travel_ECU **14** adds frequency "1" to the class corresponding to the change amount Δx of the current lateral position x in the histogram generated up to the previous cycle.

In a subsequent step S**204**, the travel_ECU **14** calculates, on the basis of the updated histogram, the distribution width Wx of the lateral position x of the oncoming moving body O.

In a subsequent step S**205**, the travel_ECU **14** acquires the target traveling path Rm set in the host vehicle M.

In a subsequent step S**206**, the travel_ECU **14** sets the risk determination region on the road. That is, the travel_ECU **14** sets the risk determination region in accordance with the distribution width Wx of the lateral position x of the oncoming moving body O with reference to a map or the like set in advance.

In a subsequent step S**207**, the travel_ECU **14** calculates the risk degree R of the oncoming moving body O on the basis of the risk determination region, and subsequently exits the subroutine. That is, the travel_ECU **14** calculates, as the risk degree R for the oncoming moving body O, the risk degree R of the risk determination region to be penetrated by the target traveling path Rm of the host vehicle M.

In the main routine in FIG. **7**, upon proceeding from step S**103** to step S**104**, the travel_ECU **14** performs upper limit processing on the risk degree R. This upper limit processing is processing for preventing the risk degree R from becoming unnecessarily large due to a factor other than the wandering of the oncoming moving body O.

In this upper limit processing, the travel_ECU **14**, in a case where the risk degree R is expected to increase due to a factor other than the wandering of the oncoming moving body O, limits the risk degree R to, for example, "4" or less.

The upper limit processing for this risk degree R is executed according to the flowchart of a risk upper limit processing subroutine illustrated in FIG. **9**, for example.

When the subroutine starts, the travel_ECU **14** acquires, in step S**301**, the target traveling path Rm set for the host vehicle M.

In a subsequent step S**302**, the travel_ECU **14** calculates the predicted traveling path Ro of the oncoming moving body O on the basis of the current velocity and movement direction of the oncoming moving body O.

In a subsequent step S**303**, the travel_ECU **14** calculates a predicted collision point Pc and a collision angle $9c$ of the host vehicle M and the oncoming moving body O. For example, in a case where it is presumed that the oncoming moving body O moved on a predicted traveling path Ro (refer to O' in FIG. **4**), the travel_ECU **14** calculates, as the predicted collision point Pc of the host vehicle M and the oncoming moving body O, a point at which the longitudinal time-to-collision TTCz and the lateral time-to-collision TTCx are both "0" or less (refer to FIG. **4**), for example. Further, in a case where it is presumed that the oncoming moving body O moved to the predicted collision point Pc, the travel_ECU **14** calculates the collision angle $9c$ on the basis of a relative angle between the oncoming moving body O' after moving and the host vehicle M.

In a subsequent step S**304**, the travel_ECU **14** checks whether a blinker of the oncoming moving body O is blinking.

Then, in step S**304**, in a case where the travel_ECU **14** determines that a blinker of the oncoming moving body O is blinking (step S**304**: YES), the travel_ECU **14** proceeds to step S**308**.

In step S308, for example, the travel_ECU 14 performs upper limit processing in which the risk degree R is set to "4" or less, and subsequently exits the subroutine.

That is, for example, as illustrated in FIG. 12, as a case where the risk degree R of the oncoming moving body O increases due to a factor other than wandering, a case is expected where the oncoming moving body O turns toward the traveling lane of the host vehicle M while the blinker is blinking. In such a case, the intention of the driver driving the oncoming moving body O is clear, and it is expected that the driver is sufficiently aware of the host vehicle M. Accordingly, in such a case, it is hard to imagine sudden entry of the oncoming moving body O into the traveling lane of the host vehicle M at the timing at which collision with the host vehicle M is highly likely, and thus the control content is restricted by upper limit processing.

On the other hand, in step S304, in a case where the travel_ECU 14 determines that the blinker of the oncoming moving body O is not blinking (step S304: NO), the travel_ECU 14 proceeds to step S305.

In step S305, the travel_ECU 14 checks whether, compared with before, the behavior of the oncoming moving body O is changing into an advantageous situation in which collision with the host vehicle M is avoidable. That is, the travel_ECU 14 checks whether the predicted traveling path Ro of the oncoming moving body O calculated in step S302 and the predicted collision point Pc and the collision angle $9c$ of the oncoming moving body O calculated in step S303 are changing into an advantageous situation. Here, for example, in a case where the lateral velocity component Vox of the oncoming moving body O starts to decline, in general, the predicted traveling path Ro of the oncoming moving body O is angled toward the host vehicle M. Further, for example, in a case where the lateral velocity component Vox of the oncoming moving body O starts to decline, the predicted collision point Pc of the oncoming moving body O moves to the host vehicle M. Further, for example, in a case where the lateral velocity component Vox of the oncoming moving body O starts to decline, the collision angle $9c$ changes so as to increase. Thus, the travel_ECU 14 determines that the behavior of the oncoming moving body O has changed to be advantageous in a case where at least one of the following is true: the predicted traveling path Ro is angled toward the host vehicle M, the predicted collision point Pc is moved to the host vehicle M, or the collision angle $9c$ is changed so as to increase.

Then, in a case where the travel_ECU 14 determines that the behavior of the oncoming moving body O has changed to advantageous (step S305: YES), the travel_ECU 14 proceeds to step S308.

Upon proceeding to step S308, the travel_ECU 14 performs upper limit processing in which the risk degree R is set to "4" or less, for example, and subsequently exits the subroutine.

On the other hand, in step S305, in a case where the travel_ECU 14 determines that the behavior of the oncoming moving body O changed to be disadvantageous (step S305: NO), the travel_ECU 14 proceeds to step S306.

In step S306, the travel_ECU 14 checks whether a stationary object such as a parked vehicle is present near the oncoming moving body O in the oncoming lane.

Then, in step S306, in a case where the travel_ECU 14 determines that a parked vehicle or the like is present in the oncoming lane (step S306: YES), the travel_ECU 14 proceeds to step S308.

Upon proceeding to step S308, the travel_ECU 14 performs upper limit processing in which the risk degree R is set to "4" or less, for example, and subsequently exits the subroutine.

That is, as illustrated in FIG. 13, for example, as a case where the risk degree R of the oncoming moving body O increases due to a factor other than wandering, a case is expected where the oncoming moving body O avoids a stationary object such as a parked vehicle in the oncoming lane. In such a case, the intention of the driver driving the oncoming moving body O is clear, and it is expected that the driver is sufficiently aware of the host vehicle M. In addition, in such a case, it is expected that the risk degree R calculated on the basis of the risk determination region temporarily increases and subsequently starts to decrease quickly. Accordingly, in such a case, it is hard to imagine sudden entry of the oncoming moving body O into the traveling lane of the host vehicle M at the timing at which collision with the host vehicle M is highly likely, and thus the control content is restricted by upper limit processing.

On the other hand, in step S306, in a case where the travel_ECU 14 determines that a parked vehicle or the like is not present in the oncoming lane (step S306: NO), the travel_ECU 14 proceeds to step S307.

In step S307, the travel_ECU 14 checks whether the oncoming moving body O is merging from a branch road into the oncoming lane.

Then, in step S307, in a case where the travel_ECU 14 determines that the oncoming moving body O is merging from a branch road (step S307: YES), the travel_ECU 14 proceeds to step S308.

Upon proceeding to step S308, the travel_ECU performs upper limit processing in which the risk degree R is set to "4" or less, for example, and subsequently exits the subroutine.

That is, for example, as illustrated in FIG. 14, as a case where the risk degree R of the oncoming moving body O increases due to a factor other than wandering, a case is expected where the oncoming moving body O enters the oncoming lane from a branch road or the like. In such a case, the intention of the driver driving the oncoming moving body O is clear, and it is expected that the driver is sufficiently aware of the host vehicle M. In addition, in such a case, it is expected that the risk degree R calculated on the basis of the risk determination region temporarily increases and subsequently starts to decrease quickly. Accordingly, in such a case, it is hard to imagine sudden entry of the oncoming moving body O into the traveling lane of the host vehicle M at the timing of collision with the host vehicle M, and thus the control content is restricted by upper limit processing.

On the other hand, in step S307, in a case where the travel_ECU 14 determines that the oncoming moving body O is not merging from a branch path (step S307: NO), the travel_ECU 14 exits the subroutine.

In the main routine of FIG. 7, upon proceeding from step S104 to step S105, the travel_ECU 14 performs reduction processing on the risk degree R. This reduction processing is processing for reducing, as appropriate, a risk level LV of preliminary collision avoidance control (described below) permitted in accordance with the risk degree R. This risk level LV is reduced on the basis of a relative relationship between the host vehicle M and the oncoming moving body O. For example, even in a case where the wandering of the oncoming moving body O is significant and the risk degree R of the oncoming moving body O entering the traveling lane of the host vehicle M is high, when the oncoming

moving body O is far away, the likelihood of the host vehicle M colliding with the oncoming moving body O is low. Therefore, in such a case, the travel_ECU 14 reduces the risk level LV of the preliminary collision avoidance control permitted in accordance with the risk degree R to prevent excessive preliminary collision avoidance control from being executed.

This reduction processing is executed according to the flowchart of a reduction processing subroutine illustrated in FIG. 10, for example.

When the subroutine starts, the travel_ECU 14 checks whether the longitudinal time-to-collision TTCz for the oncoming moving body O is less than a fourth threshold value Tth4 (where, Tth1<Tth4) set in advance.

Then, in step S401, in a case where the travel_ECU 14 determines that the longitudinal time-to-collision TTCz is equal to or greater than the fourth threshold value Tth4 (step S401: NO), the travel_ECU 14 proceeds to step S402.

In step S402, the travel_ECU permits the preliminary collision avoidance control corresponding to when the risk degree R is "2" or less, and subsequently exits the subroutine. In this way, the travel_ECU 14 permits control up to the preliminary collision avoidance control corresponding to when the risk degree R is "2" even when the current risk degree R is "9", for example. Further, in a case where the current risk degree R is "2", for example, the travel_ECU 14 permits the preliminary collision avoidance control corresponding to when the risk degree R is "2". Note that, in the present embodiment, the preliminary collision avoidance control corresponding to when the risk degree R is "2" or less is the collision avoidance control of the risk level LV=1 associated with the "caution region" of the risk determination region.

On the other hand, in step S401, in a case where the travel_ECU 14 determines that the longitudinal time-to-collision TTCz is less than the fourth threshold value Tth4 (step S401: YES), the travel_ECU 14 proceeds to step S403.

In step S403, the travel_ECU 14 checks whether the longitudinal time-to-collision TTCz is less than a fifth threshold value Tth5 (where, Tth1≤Tth5<Tth4) set in advance.

Then, in step S403, in a case where the travel_ECU 14 determines that the longitudinal time-to-collision TTCz is equal to or greater than the fifth threshold value Tth5 (step S403: NO), the travel_ECU 14 proceeds to step S404.

In step S404, the travel_ECU 14 permits the preliminary collision avoidance control corresponding to when the risk degree R is "4" or less, and subsequently exits the subroutine. In this way, the travel_ECU 14 permits control up to the preliminary collision avoidance control corresponding to when the risk degree R is "4" even when the current risk degree R is "9", for example. Further, in a case where the current risk degree R is "4", for example, the travel_ECU 14 permits the preliminary collision avoidance control corresponding to when the risk degree R is "4". Note that, in the present embodiment, the preliminary collision avoidance control corresponding to when the risk degree R is greater than "2" and "4" or less is the collision avoidance control of the risk level LV=2 associated with the "warning region" of the risk determination region.

On the other hand, in step S403, in a case where the travel_ECU 14 determines that the longitudinal time-to-collision TTCz is less than the fifth threshold value Tth5 (step S403: YES), the travel_ECU 14 proceeds to step S405.

In step S405, the travel_ECU permits the preliminary collision avoidance control corresponding to when the risk degree R is "9" or less, and subsequently exits the subrou-

tine. In this way, the travel_ECU 14 permits the preliminary collision avoidance control corresponding to all risk degrees R, for example. That is, in a case where the current risk degree R is "9", for example, the travel_ECU 14 permits the preliminary collision avoidance control corresponding to when the risk degree R is "9". Further, in a case where the current risk degree R is "4", for example, the travel_ECU 14 permits the preliminary collision avoidance control corresponding to when the risk degree R is "4". Note that, in the present embodiment, the preliminary collision avoidance control corresponding to when the risk degree R is greater than "4" and "9" or less is the collision avoidance control of the risk level LV=3 associated with the "danger region" of the risk determination region.

In the main routine in FIG. 7, upon proceeding from step S105 to step S106, the travel_ECU 14 performs a forced control intervention determination with respect to the oncoming moving body O. This forced control intervention is a determination for forcibly executing preliminary collision avoidance control for the risk level LV=3 in an emergency such as in a case where the oncoming moving body O continues to move directly in the direction of the host vehicle M, for example.

This forced control intervention determination is made according to a forced control intervention determination subroutine illustrated in FIG. 11, for example.

When the subroutine starts, in step S501, the travel_ECU 14 checks whether the oncoming moving body O has continued to move directly in the direction of the host vehicle M for a set time (for example, a predetermined frame).

Then, in step S501, in a case where the travel_ECU 14 determines that the oncoming moving body O is not moving directly in the direction of the host vehicle M (step S501: NO), the travel_ECU 14 exits the subroutine.

On the other hand, in step S501, in a case where the travel_ECU 14 determines that the oncoming moving body O is moving directly in the direction of the host vehicle M (step S501: YES), the travel_ECU 14 proceeds to step S502.

In step S502, the travel_ECU 14 corrects the risk degree R for the oncoming moving body O to "9" and corrects the risk level LV permitted for the oncoming moving body O to "3", for example, and subsequently exits the subroutine.

In the main routine of FIG. 7, upon proceeding from step S106 to step S107, the travel_ECU 14 determines the kind of preliminary collision avoidance action to be taken in response to the oncoming moving body O. This preliminary collision avoidance action is determined on the basis of the risk level LV currently permitted for the oncoming moving body O and the current risk degree R currently set for the oncoming moving body O, for example.

Herein, for example, as illustrated in FIG. 15, in a case where the current risk degree R for the oncoming moving body O is "0", "0" is set as the risk level for the oncoming moving body O. In a case where the risk level LV=0, the travel_ECU 14 prohibits output of an alert or the like for notifying the driver of the presence of the oncoming moving body O. Further, in the case where the risk level LV=0, the travel_ECU 14 prohibits avoidance control in the longitudinal direction (front-rear direction of the host vehicle M) in response to the oncoming moving body O.

Furthermore, in the case where the risk level LV=0, the travel_ECU 14 prohibits avoidance control in the lateral direction (vehicle width direction of the host vehicle M) in response to the oncoming moving body O.

Further, for example, as illustrated in FIG. 15, in a case where the risk degree R is greater than "0" and control up to

the risk level LV=1 is permitted in response to the oncoming moving body O, the travel_ECU **14** prohibits output of an alert or the like for notifying the driver of the presence of the oncoming moving body O.

Further, in a case where the risk degree R is greater than "0" and control up to the risk level LV=1 is permitted in response to the oncoming moving body O, the travel_ECU **14** performs avoidance control in the longitudinal direction (front-rear direction of the host vehicle M) in response to the oncoming moving body O. In this avoidance control, the travel_ECU **14** permits first acceleration suppression control, for example, in place of the braking control. In this first acceleration suppression control, a first acceleration suppression amount is set, as appropriate, only in a case where the host vehicle M is accelerating (including a case where the host vehicle M is about to accelerate), for example. The first acceleration suppression amount is set so as to increase as the longitudinal time-to-collision TTCz decreases, on the basis of a map or the like set in advance, for example.

Further, in a case where the risk degree R is greater than "0" and control up to the risk level LV=1 is permitted in response to the oncoming moving body O, the travel_ECU **14** performs avoidance control in the lateral direction (vehicle width direction of the host vehicle M) in response to the oncoming moving body O. In this avoidance control, the travel_ECU **14** permits steering control within a range in which no deviation occurs from the traveling lane in which the host vehicle M is traveling, for example. In this steering control, an avoidance amount by steering is set as appropriate. The avoidance amount is set so as to increase as the lateral time-to-collision TTCx decreases, on the basis of a map or the like set in advance, for example. Note that, in some embodiments, the steering wheel steering speed permitted for this steering control is limited to about 10 deg/s, for example.

Further, for example, as illustrated in FIG. **15**, in a case where the risk degree R is greater than "2" and control up to the risk level LV=2 is permitted in response to the oncoming moving body O, the travel_ECU **14** sets an alert or the like for notifying the driver of the presence of the oncoming moving body O.

Further, in a case where the risk degree R is greater than "2" and control up to the risk level LV=2 is permitted in response to the oncoming moving body O, the travel_ECU **14** performs avoidance control in the longitudinal direction in response to the oncoming moving body O. In this avoidance control, the travel_ECU **14** permits second acceleration suppression control in place of braking control. In this second acceleration suppression control, a second acceleration suppression amount is set as appropriate only in a case where the host vehicle M is accelerating (including a case where the host vehicle M is about to accelerate), for example. The second acceleration suppression amount is set so as to increase as the longitudinal time-to-collision TTCz decreases, on the basis of a map or the like set in advance, for example. Note that the second acceleration suppression amount is set to be greater than the first acceleration suppression amount. For example, the deceleration (suppression amount) obtained when the driver releases the accelerator is provided as the upper limit for the second acceleration suppression amount.

Further, in a case where the risk degree R is greater than "2" and control up to the risk level LV=2 is permitted in response to the oncoming moving body O, the travel_ECU **14** performs avoidance control in the lateral direction in response to the oncoming moving body O. In this avoidance control, the travel_ECU **14** permits steering control to a

position at which the host vehicle M straddles a lane marker, for example. In this steering control, the avoidance amount by steering is set as appropriate. The avoidance amount is set so as to increase as the lateral time-to-collision TTCx decreases, on the basis of a map or the like set in advance, for example. Note that, in some embodiments, the steering wheel steering speed permitted for this steering control is limited to about 80 deg/s, for example.

Further, for example, as illustrated in FIG. **15**, in a case where the risk degree R is greater than "4" and control up to the risk level LV=3 is permitted in response to the oncoming moving body O, the travel_ECU **14** sets an alert or the like for notifying the driver of the presence of the oncoming moving body O.

Further, in a case where the risk degree R is greater than "4" and control up to the risk level LV=3 is permitted in response to the oncoming moving body O, the travel_ECU **14** performs avoidance control in the longitudinal direction in response to the oncoming moving body O. In this avoidance control, the travel_ECU **14** permits braking control. In this braking control, for example, the braking amount is set as appropriate. The braking amount is set so as to increase as the time-to-collision TTCz decreases, on the basis of a map or the like set in advance. Note that this braking amount is, in one example, set with the first target deceleration a1 (0.4 G, for example) of the emergency collision avoidance control described above as the limit.

Further, in a case where the risk degree R is greater than "4" and control up to the risk level LV=3 is permitted in response to the oncoming moving body O, the travel_ECU **14** performs avoidance control in the lateral direction in response to the oncoming moving body O. In this avoidance control, the travel_ECU **14** permits steering control to a position at which the host vehicle M travels across a lane marker, for example. In this steering control, the avoidance amount by steering is set as appropriate, for example. The avoidance amount is set so as to increase as the lateral time-to-collision TTCx decreases, on the basis of a map or the like set in advance, for example. Note that, in some embodiments, the steering wheel steering speed permitted for this steering control is limited to about 240 deg/s, for example.

Upon proceeding from step S**107** to step S**108**, the travel_ECU **14** checks whether control intervention is used in response to the oncoming moving body O, that is, checks whether a predetermined control amount has been set in step S**107** described above.

Then, in step S**108**, in a case where the travel_ECU **14** determines that control intervention is not used (step S**108**: NO), the travel_ECU **14** exits the routine.

On the other hand, in a case where the travel_ECU **14** determines that control intervention is used in step S**108** (step S**108**: YES), the travel_ECU **14** proceeds to step S**109**.

In step S**109**, the travel_ECU **14** checks whether the oncoming moving body O has entered the target traveling region Am of the host vehicle M.

Then, in step S**109**, in a case where the travel_ECU **14** determines that the oncoming moving body O is present outside the target traveling region Am of the host vehicle M (step S**109**: NO), the travel_ECU **14** proceeds to step S**110**.

In step S**110**, the travel_ECU **14** executes preliminary collision avoidance control, and subsequently exits the routine. That is, the travel_ECU **14** executes preliminary collision avoidance control on the basis of the control amount set in step S**107**.

On the other hand, in step S**109**, in a case where the travel_ECU **14** determines that the oncoming moving body

O is present inside the target traveling region Am of the host vehicle M (step S109: YES), the travel_ECU **14** proceeds to step S111.

In step S111, the travel_ECU **14** transitions the control in response to the oncoming moving body O from preliminary collision avoidance control to emergency collision avoidance control, and then exits the routine.

According to such an embodiment, the travel_ECU **14** recognizes the oncoming moving body O on the basis of the traveling environment information. Further, the travel_ECU **14** acquires the distribution characteristics of the lateral position x associated with movement of the oncoming moving body O. Further, the travel_ECU **14** variably sets the risk determination region for calculating the risk degree R that decreases as the distance outward from the center of the oncoming lane in the width direction of the oncoming moving body O increases so that the risk degree R relatively increases as the distribution characteristics of the lateral position x tend toward dispersion. Furthermore, the travel_ECU **14** calculates the risk degree R for the oncoming moving body O in accordance with the overlap state of the target traveling path Rm of the host vehicle M and the risk determination region. Then, the travel_ECU **14** recognizes the oncoming moving body O as an obstacle in accordance with the risk degree R, and performs the preliminary collision avoidance control prior to the emergency collision avoidance control in response to the oncoming moving body O recognized as the obstacle.

As a result, sufficient safety can be ensured even in a case where the oncoming moving body O, such as an oncoming vehicle, suddenly enters the traveling lane of the host vehicle M. That is, the travel_ECU **14** performs the preliminary collision avoidance control in accordance with the risk degree R in response to the oncoming moving body O before the oncoming moving body O enters the target traveling region Am of the host vehicle M. Accordingly, even in a case where the oncoming moving body O suddenly travels across the lane marker and enters in front of the host vehicle M, the emergency collision avoidance control can be performed with well-prepared state.

In this case, the travel_ECU **14** acquires the distribution characteristics of the lateral position x associated with the movement of the oncoming moving body O, and variably sets the risk determination region so that the more the distribution characteristics of the lateral position x tend toward dispersion, the greater the relative increase in the risk degree R. In this way, the risk degree R that is stable can be calculated even in a case where the oncoming moving body O is meandering by wandering or the like and the relationship between the risk determination region and the target traveling path Rm of the host vehicle M fluctuates. Accordingly, the risk due to wandering or the like of the oncoming moving body O can be accurately determined, and appropriate preliminary collision avoidance control can be achieved.

Further, the travel_ECU **14** is configured to set the lateral position x relative to the host vehicle M when the oncoming moving body O is first detected as the reference lateral position x0. The travel_ECU **14** then generates, as the distribution characteristics of the lateral position x, a histogram by aggregating, as a class, the change amount Δx in the lateral position x of the oncoming moving body O relative to the reference lateral position x0, for every predetermined change amount Δx. Consequently, whether the oncoming moving body O is wandering can be easily determined.

Further, the travel_ECU **14** variably sets the risk determination region so that the calculated risk degree relatively

increases as the distribution width Wx of the lateral position x in the distribution characteristics of the lateral position x widens. Consequently, the appropriate preliminary collision avoidance control in accordance with the wandering state of the oncoming moving body O can be achieved.

Further, the travel_ECU **14** varies the control level (risk level) permitted to the preliminary collision avoidance control in accordance with the value of the longitudinal time-to-collision TTCz. This makes it possible to achieve appropriate preliminary collision avoidance control in response to the oncoming moving body O.

Herein, in the embodiment described above, the image recognition_ECU **13**, the travel_ECU **14**, the CP_ECU **21**, the E/G_ECU **22**, the T/M_ECU **23**, the BK_ECU **24**, the PS_ECU **25** and the like are each constituted by a known microcomputer including a central processing unit (CPU), a read access memory (RAM), a read only memory (ROM), a non-volatile storage unit, and the like, and peripheral devices thereof. In the ROM, fixed data such as programs executed by the CPU and data tables or the like are stored in advance. Note that all or some of the functions of the processor may be configured by a logic circuit or an analog circuit. Further, the processing of the various kinds of programs may be realized by an electronic circuit such as a field-programmable gate array (FPGA).

The disclosure described in the above embodiments is not limited to the embodiments, but in addition, various modifications can be made without departing from the spirit and scope of the invention in an implementation stage. Furthermore, the above embodiments include technologies in various stages and various kinds of technologies can be extracted with an appropriate combination of disclosed configuration requirements.

For example, in a case where several configuration requirements are deleted from all configuration requirements disclosed in the above embodiments, if the mentioned problems can be solved and the advantageous effects can be achieved, the configuration from which the configuration requirements are deleted can be extracted as a technology.

For example, instead of the risk degree R cumulatively calculated, the risk degree R directly calculated from the risk determination region can be used to perform the preliminary collision avoidance control.

The invention claimed is:

1. A vehicle driving assist device comprising:
a traveling environment recognizer configured to recognize traveling environment information about a traveling environment outside a vehicle;
an obstacle recognizer configured to recognize, based on the traveling environment information, an obstacle present on a target traveling path of the vehicle;
an emergency collision avoidance controller configured to, upon determination that the vehicle is highly likely to collide with the obstacle, perform emergency collision avoidance control for avoiding collision of the vehicle with the obstacle;
an oncoming moving body recognizer configured to recognize, based on the traveling environment information, an oncoming moving body moving in an oncoming lane adjacent to a traveling lane of the vehicle and having a velocity component in a direction opposite to a traveling direction of the vehicle;
a lateral position distribution characteristics acquisition unit configured to acquire distribution characteristics of a lateral position of the oncoming moving body based on a positional deviation of the oncoming moving body from a reference lateral position in the oncoming lane;

a risk determination region setting unit configured to set, based on the distribution characteristics of the lateral position, a risk determination region for the oncoming moving body,

wherein the risk determination region extends in a lateral direction from a center of the oncoming lane and covers the traveling lane of the vehicle, and comprises sub-regions assigned different risk degrees,

wherein one of the sub-regions includes a danger region that is closest to the oncoming moving body and corresponds to a highest risk degree, and

wherein the risk determination region setting unit is further configured to adjust widths of the sub-regions in accordance with a lateral position variation of the oncoming moving body relative to the reference lateral position, such that as the lateral position variation increases and the distribution characteristics of the lateral position tend to disperse, the danger region expands in the lateral direction while at least one other sub-region other contracts;

a risk degree calculator configured to determine a risk degree for the oncoming moving body in accordance with an overlap state between the target traveling path of the vehicle and the risk determination region; and

a preliminary collision avoidance controller configured to recognize the oncoming moving body as the obstacle in accordance with the risk degree, and perform preliminary collision avoidance control in response to the oncoming moving body recognized as the obstacle prior to the emergency collision avoidance control.

2. The vehicle driving assist device according to claim **1**, wherein the lateral position distribution characteristics acquisition unit is configured to set, as the reference lateral position, a lateral position relative to the vehicle when the oncoming moving body is firstly detected, and generate, as the distribution characteristics of the lateral position, a histogram by aggregating, as a class, change amounts in the lateral position of the oncoming moving body relative to the reference lateral position, for every predetermined change amount.

3. The vehicle driving assist device according to claim **1**, wherein the risk determination region setting unit is configured to variably set the risk determination region so that the risk degree calculated relatively increases as a distribution width of the lateral position in the distribution characteristics widens.

4. The vehicle driving assist device according to claim **2**, wherein the risk determination region setting unit is configured to variably set the risk determination region so that the risk degree calculated relatively increases as a distribution width of the lateral position in the distribution characteristics widens.

5. The vehicle driving assist device according to claim **1**, wherein the risk degree calculator is configured to perform upper limit processing in which a preset value is set as an upper limit of the risk degree.

6. The vehicle driving assist device according to claim **2**, wherein the risk degree calculator is configured to perform upper limit processing in which a preset value is set as an upper limit of the risk degree.

7. The vehicle driving assist device according to claim **3**, wherein the risk degree calculator is configured to perform upper limit processing in which a preset value is set as an upper limit of the risk degree.

8. The vehicle driving assist device according to claim **4**, wherein the risk degree calculator is configured to perform

upper limit processing in which a preset value is set as an upper limit of the risk degree.

9. The vehicle driving assist device according to claim **1**, wherein the preliminary collision avoidance controller is configured to vary a control level permitted to the preliminary collision avoidance control based on a relative distance and a relative velocity of the vehicle to the oncoming moving body in a front-rear direction.

10. The vehicle driving assist device according to claim **2**, wherein the preliminary collision avoidance controller is configured to vary a control level permitted to the preliminary collision avoidance control based on a relative distance and a relative velocity of the vehicle to the oncoming moving body in a front-rear direction.

11. The vehicle driving assist device according to claim **3**, wherein the preliminary collision avoidance controller is configured to vary a control level permitted to the preliminary collision avoidance control based on a relative distance and a relative velocity of the vehicle to the oncoming moving body in a front-rear direction.

12. The vehicle driving assist device according to claim **4**, wherein the preliminary collision avoidance controller is configured to vary a control level permitted to the preliminary collision avoidance control based on a relative distance and a relative velocity of the vehicle to the oncoming moving body in a front-rear direction.

13. The vehicle driving assist device according to claim **5**, wherein the preliminary collision avoidance controller is configured to vary a control level permitted to the preliminary collision avoidance control based on a relative distance and a relative velocity of the vehicle to the oncoming moving body in a front-rear direction.

14. The vehicle driving assist device according to claim **6**, wherein the preliminary collision avoidance controller is configured to vary a control level permitted to the preliminary collision avoidance control based on a relative distance and a relative velocity of the vehicle to the oncoming moving body in a front-rear direction.

15. The vehicle driving assist device according to claim **7**, wherein the preliminary collision avoidance controller is configured to vary a control level permitted to the preliminary collision avoidance control based on a relative distance and a relative velocity of the vehicle to the oncoming moving body in a front-rear direction.

16. The vehicle driving assist device according to claim **8**, wherein the preliminary collision avoidance controller is configured to vary a control level permitted to the preliminary collision avoidance control based on a relative distance and a relative velocity of the vehicle to the oncoming moving body in a front-rear direction.

17. A vehicle driving assist device comprising one or more ECUs configured to:

recognize traveling environment information about a traveling environment outside a vehicle;

recognize based the traveling environment information, an obstacle present on a target traveling path of the vehicle;

upon determination that the vehicle is highly likely to collide with the obstacle, perform emergency collision avoidance control for avoiding collision of the vehicle with the obstacle;

recognize, based on the traveling environment information, an oncoming moving body moving in an oncoming lane adjacent to a traveling lane of the vehicle and having a velocity component in a direction opposite to a traveling direction of the vehicle;

acquire distribution characteristics of a lateral position of the oncoming moving body based on a positional deviation of the oncoming moving body from a reference lateral position in the oncoming lane;

set, based on the acquired distribution characteristics of the lateral position, a risk determination region for the oncoming moving body,

wherein the risk determination region extends in a lateral direction from a center of the oncoming lane and covers the traveling lane of the vehicle, and comprises sub-regions assigned different risk degrees,

wherein one of the sub-regions includes a danger region that is closest to the oncoming moving body and corresponds to a highest risk degree, and

wherein the risk determination region setting unit is further configured to adjust widths of the sub-regions in accordance with a lateral position variation of the oncoming moving body relative to the reference lateral position, such that as the lateral position variation increases and the distribution characteristics of the lateral position tend to disperse, the danger region expands in the lateral direction while at least one other sub-region contracts;

determine the risk degree for the oncoming moving body in accordance with an overlap state between the target traveling path of the vehicle and the risk determination region; and

recognize the oncoming moving body the obstacle in accordance with the risk degree, and perform preliminary collision avoidance control in response to the oncoming moving body recognized as the obstacle prior to the emergency collision avoidance control.

18. The vehicle driving assist device according to claim **1**, wherein the risk degree calculator is configured to reduce the risk degree upon determining that behavior of the oncoming moving body is identifiable as not moving toward the vehicle.

19. The vehicle driving assist device according to claim **1**, wherein the preliminary collision avoidance controller has setting information for brake operation and steering operation for performing the preliminary collision avoidance control, the setting information being defined for each different risk degree, and

wherein the preliminary collision avoidance controller is configured to perform the preliminary collision avoidance control based on the setting information corresponding to the determined risk degree.

20. The vehicle driving assist device according to claim **19**, wherein the preliminary collision avoidance controller is configured to:

reduce the risk degree based on a relative distance and a relative velocity of the vehicle to the oncoming moving body; and

perform the preliminary collision avoidance control based on the setting information corresponding to the reduced risk degree.

21. The vehicle driving assist device according to claim **19**, wherein the preliminary collision avoidance controller is configured to:

increase the risk degree upon determining that behavior of the oncoming moving body is identifiable as moving toward the vehicle; and

perform the preliminary collision avoidance control based on based on the setting information corresponding to the increased risk degree.

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