(19) Japan Patent Office (JP)

(12) **Japanese Unexamined Patent Application Publication** (A)

(11) Japanese Unexamined Patent Application Publication Number

H07-125567

(43) Publication date: May 16, 1995

(51) Int. Cl.[6]	Recognition codes	Patent Office Serial Numbers	F1	Technology Indication Area
B 60 K 31/00	Z			
B 60 R 21/00	C	9434-3D		
F 02 D 29/02	301 D		G 01 S 11/00	B
			17/88	A
		4240-5J		

Request for Examination: Not Made Number of inventions 1 OL (total 7 pages) Continued on last page

(21) Application number H05-275184

(22) Date of application November 4, 1993

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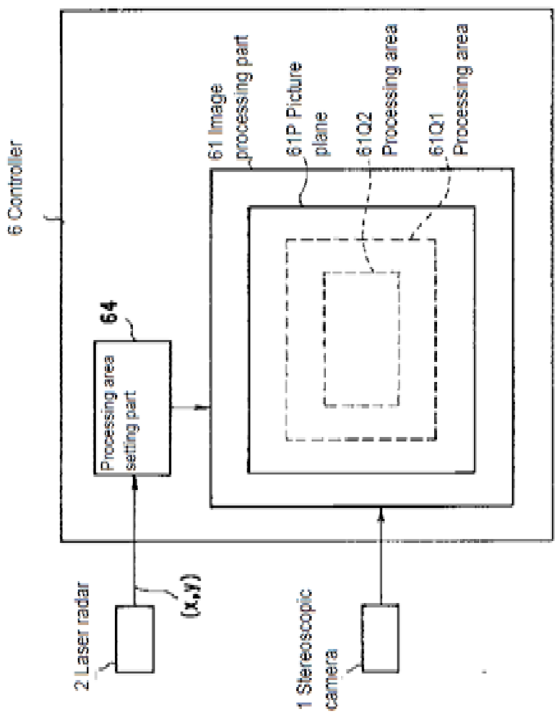
(54) Preceding car detecting mechanism of car cruise control apparatus

(57) Abstract

PURPOSE: To detect a preceding car rapidly reducing the time required for image processing.

CONSTITUTION: A laser radar 2 detects a preceding object by emitting a laser beam in the front direction while scanning. Additionally, a stereoscopic camera 1 captures an image of the scene in front of one's own car and transmits the image thus captured to an image processing part 61. A processing area setting part 64 sets the processing areas $61Q_1$ and $61Q_2$ in the picture plane 61P of the image processing part 61 corresponding to the position of the object which has been detected by the laser radar 2. The image processing part 61 recognizes the preceding car by processing only the image data within the processing area which has thus been set.



CLAIMS

Claim 1 A preceding car detecting mechanism of car cruise control apparatus which performs image processing of images obtained by capturing images of the situation in front of one's own car and recognizing preceding s with a camera means, and which controls engine output so as to travel while following the preceding vehicle has:

a laser radar that emits a laser beam in the horizontal plane to scan in the direction in front of one's own car and that receives the reflected laser beam to detect the position of objects present in front of one's own car; and

an image processing means that sets the processing area in the picture plane corresponding to the position of objects that have been detected by the laser radar when the image undergoes image processing and a preceding car is recognized, and that performs image processing only of these processing areas to recognize preceding cars.

Detailed Description of the Invention

0001

Area of Use in Industry

The present invention pertains to car cruise control apparatus. More specifically, it pertains to apparatus intended to recognize preceding cars by image processing and to facilitate rapid image processing and reduce misrecognition when a car is traveling while following the recognized preceding vehicle.

0002

Prior Art

Constant travel speed control apparatus as well as apparatus to control inter-vehicle distance have been commercialized to reduce the operations associated with driving a car.

0003

"Constant travel speed control apparatus" is also known as "automatic speed control" or "cruise control." The speed that has been set in cars equipped with this apparatus is maintained by pushing a switch and removing one's foot from the accelerator pedal. The speed setting can be changed by using a control switch. This function is canceled when the driver presses the brake pedal, the clutch pedal, or operates the gear shift, or the like.

0004

The following functions have been added in order to maintain safety when using this sort of constant travel speed control apparatus. Thus, a laser radar or the like is used to detect the distance from the preceding car, and warning is issued to the driver when the car traveling in front becomes abnormally close, and the gear shift is shifted down from fourth gear (overdrive) to third gear to turn overdrive off and make use of engine braking.

0005

By pressing a switch in a car equipped with "apparatus to control inter-vehicle distance," the target inter-vehicle distance is calculated from the speed of one's own vehicle at that time, the inter-vehicle distance to the preceding car is detected thereby, and engine braking or the brake are used so that the inter-vehicle distance with the preceding car is brought to the target inter-vehicle distance, and one's own car travels behind the preceding car at that distance. In this case, the detection of the inter-vehicle distance from the preceding car is found by image processing of the image captured by a camera, or is calculated from laser radar, or the like.

0006

Problems the Invention Is Intended to Resolve

However, in the "constant travel speed apparatus" of the prior art, when following a preceding vehicle which is traveling at low speed, the driver must reduce speed and disengaged the constant travel speed control. Thus, on congested roads, this operation is complex, troublesome and increases risk.

0007

Meanwhile, in "inter-vehicle distance control apparatus" of the prior art, control cannot be performed when there is no preceding vehicle.

0008

The inventors of this application have developed a "vehicle travel control apparatus" that combines the functions of a constant travel speed apparatus and an inter-vehicle distance control apparatus. As will be described in detail below, cars that are equipped with this "car cruise control apparatus" maintains a preset constant travel speed even when there is no preceding car present, follows the preceding car while maintaining the target inter-vehicle distance when there is a preceding car present, and moreover performs braking control when a vehicle cuts in ahead or one's own vehicle is traveling at high speed and begins following a preceding vehicle which is traveling at low speed. By using this "preceding car cruise control apparatus" when traveling in the main lanes of an expressway, the driver can drive the vehicle simply by using steering wheel controls to realize so-called "easy driving." Moreover, the apparatus can contribute to increased safety in view of the fact that it is possible to avoid the danger of coming too close to preceding cars and having a rear end collision, even if the driver is distracted and looks off to the side or falls asleep at the wheel.

0009

It is therefore an objective of the "car travel control apparatus" of this invention to make it possible to perform image processing rapidly and without error to recognize preceding vehicles when controlling the pursuit of preceding vehicles.

0010

Means of Solving the Problems

To achieve this objective, a preceding car detecting mechanism of car cruise control apparatus which performs image processing of images obtained by capturing images of the situation in front of one's own car and recognizing preceding vehicles with a camera means, and which controls engine output so as to travel while following the preceding vehicle has: a laser radar that emits a laser beam in the horizontal plane to scan in the direction in front of one's own car and that receives the reflected laser beam to detect the position of objects present in front of one's own car; and an image processing means that sets the processing area in the picture plane corresponding to the position of objects that have been detected by the laser radar when the image undergoes image processing and a preceding car is recognized, and that performs image processing only of these processing areas to recognize preceding cars.

0011

Operation of the Invention

In this invention, laser radar is used to detect the position of objects present in front of one's own vehicle, the processing area within the picture plane is set to coincide with the detection position, image processing is performed for this processing area, and preceding vehicles are identified thereby. For example, when there is a great distance to the object detected, the processing area is made small, when this distance is close, the processing area is increased, and when the detected object shifts to the left or right, the processing area is shifted to the left or right.

0012

Embodiment of the Invention

Overall Description of the "Car Travel Control Device"

The following is a description of the car travel control apparatus. This car travel control apparatus is used when traveling on expressways and dedicated car roads (hereinafter "expressways").

0013

FIG. 1 shows a car provided with car travel control apparatus. In this drawing, 1 is a stereoscopic camera, 2 is a laser radar, 3 is a throttle actuator, 4 is a brake actuator, 5 is a control switch-information display part, 6 is a controller, 7 is a car speed sensor, 7a is a steering wheel angle sensor, 7b is a brake switch, 7c is a brake pedal switch, and 7d is an accelerator pedal switch.

0014

As shown in the front few in FIG. 2, the stereoscopic camera 1 comprises two CCD cameras 11, 12 that acquire images of the scene in front of the car, and imaging board, aperture board, and other such electronic components are mounted within the body 13 thereof. This stereoscopic camera 1 is mounted in the vicinity of the rearview mirror on the interior of the car. The view field angles of each of the cameras 11, 12 are each 23° in the horizontal plane. Video signals indicating the images which have been captured by the cameras 11, 12 are transmitted to the controller 6.

0015

The following types of recognition are performed on the images captured by the two cameras 11, 12 by image processing in the image processing part of the controller 6:

- ① Recognition of cars traveling ahead (preceding cars).
- ② Recognition of the white line indicating that, out of the multiple lanes comprising the expressway, this is the lane in which one's own vehicle is traveling.
- ③ Recognition of the inter-vehicle distance between the preceding car and one's own car.

0016

Recognition of the preceding car as in ①, above, can be done for example as follows. The area surrounded by straight lines in the longitudinal direction in the image is extracted and the object that has left-right symmetry in the area that is extracted and whose position does not change very much in the image that is sequentially acquired is recognized as the preceding car.

0017

The recognition of the white lines indicating the lane of travel of one's own car as in ②, above, can be recognized for example as follows. As shown in FIG. 3 (a), the road surface ahead of the stereoscopic camera 1 is taken in and next, and the brightness of the pixels running along the four lines W1 – W4 in the horizontal direction as shown in FIG. 3 (b) is checked and the bright is selected as the candidate for the white line, and as shown in FIG. 3 (c), the linear portion from the candidate point at the top and the candidate point at the bottom are interpolated and connected to be extracted as the white line.

0018

The recognition of the inter-vehicle distance between the preceding car and one's own car as in ③, above, is performed as follows. To images as shown in FIG. 4 (a) and (b) are obtained from the two cameras 11, 12 of the stereoscopic camera 1 The image which is the same as the car image surrounded by the window on the right hand side of the image is somewhat displaced to the side in the image on the right hand side. The position of the picture having the best match is found while shifting the car image on the right hand side which is surrounded by the window one pixel at a time within the image search region on the right-hand side. Here, when the focal length of the lenses of the cameras 11, 12 as shown in FIG. 5 are designated as f; the length of the optical axis between the left and right cameras 11, 12 is designated as L; the pixel pitch of the CCD is designated as P; the number of pixels by which the right-hand image is shifted to find the match of the car images to the left and right in FIG. 4 (a) (b) is designated as n, then the distance to the car traveling ahead of one's own car (the inter-vehicle distance) R can be calculated according to triangulation using the following formula:

$R = (f \cdot L) (n \cdot P)$

0019

When the throttle actuator 3 is actuated by command from the controller to increase the throttle opening, the engine RPM increases and the speed increases. Conversely, when the throttle opening decreases, engine braking reduces the speed of the car. Following travel control and constant travel speed control, to be described below, adjusts the throttle opening. Further, when the brake actuator 4 operates in response to a command from the controller 6 and the brakes are applied, [car] will slow down rapidly. This rapid speed braking is performed when another car cuts directly in front of one's own car, when brake control is performed as described below, or other situations in which one's own car has been traveling at a high rate of speed and approaches a preceding vehicle which is traveling at a low rate of speed and the inter-vehicle distance become shorter than that the safe inter-vehicle distance. In this system, panic stops are performed only when the driver depresses the brake pedal, and not by a panic stop by controller 6 command, even when there is a sudden decrease in speed.

0020

Based on FIG. 6, the following is a general description of travel control performed primarily by the controller 6. The image processing part 61 of the controller 6 performs image processing of images captured by the stereoscopic camera 1, the image of the car in the scene in front of [one's own car] is recognized by the vehicle recognition part 61a, the white line indicating the lane in which one's own cars traveling is recognized by the lane recognition part 61b, and the inter-vehicle distance between the preceding car and one's own car is recognized by the inter-vehicle distance recognition part 61c. The target vehicle following recognition part 62 recognizes cars that are traveling in the lane in which one's own car is traveling as target vehicles to follow.

0021

When the target vehicle to follow is recognized by the target vehicle following recognition part 62, the settings command part 63 performs the following target vehicle control. Thus, the settings command part 63 uses the inter-vehicle distance recognition part 61c or the laser radar 2 to find the inter-vehicle distance D to the target vehicle which is to be followed, multiplies the setting time (for example, 2 seconds) in one's own vehicle speed V_a obtained from the speed sensor 7, and finds the target inter-vehicle distance D_0. The throttle actuator 3 is actuated so as to make the inter-vehicle distance D equal to the target inter-vehicle distance D_0, and controls engine RPM (i.e., throttle opening). In so doing, in a state where the target inter-vehicle distance D_0 is taken according to the vehicle speed, one's own vehicle travels while following the target vehicle. Thus, when the target vehicle's speed is a high rate of speed (for example, 120 km/h), the inter-vehicle distance D_0 will increase (for example, to 66.7m), and one's own vehicle will travel at high speed (for example, 120 km/h) while following the target vehicle. Moreover, when the target vehicle is traveling at low speed (for example, 60 km/h), the target inter-vehicle distance

D_0 become shorter (for example, 33.3 m), and one's own vehicle is made to follow the target vehicle while traveling at low speed (such as 60 km/h).

0022

When following travel control is performed, the target vehicle to be followed is traveling at a high rate of speed and moves ahead of one's own vehicle, and it becomes impossible to acquire the target vehicle to be followed by the stereoscopic camera 1 or the laser radar 2, or the target vehicle shifts to another lane, the settings command part 63 will control the throttle opening (i.e., engine RPM) by means of the throttle actuator 3 so as to hold one's own vehicle speed only for a predetermined settings whole time (such as 2 seconds). In other words, the system will shift from following travel control to vehicle speed control hold control (see FIG. 7).

0023

When another preceding vehicle is recognized as the target vehicle to be followed before this hold time has elapsed, which is to say when a preceding vehicle is acquired in the travel lane of one's own vehicle, the system will once again shift to following travel control, as described above (see FIG. 7).

0024

When the system transitions to constant speed travel control, the settings control part 63 will control the throttle opening (i.e., engine RPM) by means of the throttle actuator so that one's own vehicle's travel speed will be the rate of speed at the point when it became impossible to acquire a preceding vehicle or a preset setting speed V_S. If a target vehicle to be followed is acquired during constant travel control, the system will shift to following travel control (see FIG. 7).

0025

When the system is in following travel control, vehicle hold control, or constant speed travel control, the system will shift to cutting-in control when the laser radar 2 detects the presence of a vehicle that has cut in front of [one's own vehicle], and the settings command part 63 will control the throttle actuator 3 so that the throttle is fully closed for a specific length of time. When this fully close time has elapsed, the system will shift to following travel control when a target vehicle has been acquired, or will shift to constant speed travel control when no target vehicle can be acquired (see FIG. 7).

0026

In following travel control, vehicle speed hold control, constant speed travel control, or cutting-in control, the system shifts to braking travel control when the presence of a preceding car in a position which is closer than the safe inter-vehicle distance (which is determined by the relative speeds of one's own vehicle and of the preceding vehicle, and the speed of one's own vehicle, to be described below). Thus, the settings command part 63 actuates the throttle actuator 3 and fully closes the throttle, and at the same time it actuates the brake actuator 4, applying the brakes and slowing the vehicle. This braking travel control is performed when one's own vehicle is traveling at a high rate of speed and is following a preceding vehicle traveling at a low rate of speed, or when the preceding car suddenly reduces speed, and other such circumstances. Braking control is performed until the inter-vehicle distance from the preceding car returns to a safe inter-vehicle distance. When braking travel control has been completed, the system shifts to following travel control when a target vehicle to be followed is acquired, or shifts to vehicle speed hold control when no target vehicle can be acquired.

0027

When following travel control, vehicle speed hold control, constant speed travel control, cutting-in control, or braking travel control are performed, the system shifts to manual operations when the driver presses the accelerator pedal, the brake pedal, or operates the directional signal. At this time, the control command from the settings command part 63 to the throttle actuator 3 and the brake actuator 4 is released and priority is given to driver operation. When the set switch (described below) is turned on when the system is in manual operation, the system shifts to following travel control or constant speed travel control.

0028

Description of Portions Corresponding to the Salient Features of This Invention

The following is a description of the portions corresponding to the salient features of this invention. As shown in FIG. 8, the laser beam 2a that is emitted in the forward direction from the laser radar 2 which is installed in one's own vehicle scans within the horizontal plane. Therefore, by receiving the reflected laser beam 2a the laser radar 2 can detect the position of an object present in front of it. As shown in FIG. 8, the Y-axis is the front of one's own vehicle, and the X-axis is the width direction of one's own vehicle, and thus the detection position is outputted as information described by the coordinates (x. y). Further, the laser radar can be installed in the central portion of the vehicle, as shown in FIG. 10.

0029

As shown in FIG. 9, when the position coordinate data (X, Y) of a detected object is transmitted to the controller 6 from the laser radar 2, the controller 6 processing area setting part 64 sets the optimal processing area in the picture plane 61P of the image processing part 61. In other words, when distance to the detected object is short and the value of coordinate x is small, the entire area of the picture plane 61P is processed, and as the distance to the detected object becomes greater and the value of coordinate x increases, the processing areas become an hour, $61Q_1$, $61Q_2$. Also, the processing area which has been set based on the value of coordinate y is shifted to the left or right within the picture plane 61P.

0030

Specifically, the standard points α and β in the image coordinate system shown in FIG. 11 are calculated using the following formula:

β = H LINE + A/Y (A: constant)

α = CENTER + B · X/Y (B: constant)

r = B/Y… (1 meter's worth of pixels)

Next, the processing area of the image coordinate system i, j are set as follows:

Processing area = $\{(i, j) | \alpha - k_1 \cdot r < i < \alpha + k_1 \cdot r$

$\beta - k_2 \cdot r < j < \beta + k_3 \cdot r \}$

k_1, k_2, and k_3 are constants.

$k_1 = 0.9 \sim 1.5$ (m)

$k_2 = 1.5 \sim 2.5$ (m)

$k_3 = 0.1 \sim 0.5$ (m)

0031

The image processing part 61 performs image processing of only the image data within the processing area which has been set within the picture playing 61P and determines whether or not the object is a preceding car. The image processing flow is illustrated in FIG. 12.

0032

Since image processing is performed only of the data within the processing area which has been set by the image processing part 61, image processing can be done at high-speed and without errors in detecting objects in comparison to image processing in which data in the entire picture plane is processed.

0033

Effect of the Invention

As specifically described in the foregoing embodiment, this invention reduces the image processing area according to the position of objects which have been detected by laser radar and facilitates high-speed processing and reduces the misrecognition of objects.

Brief Description of the Drawings

FIG. 1 Block diagram of a car provided with car cruise control apparatus.

FIG. 2 Front view of a stereoscopic camera.

FIG. 3 Explanatory drawing describing a method of detecting white lines by image processing.

FIG. 4 Explanatory drawing describing a method of detecting inter-vehicle distance by image processing.

FIG. 5 Explanatory drawing describing triangulation by means of a stereoscopic camera.

FIG. 6 Block diagram showing a controller.

FIG. 7 State diagram showing the transition states of travel control.

FIG. 8 Explanatory drawing showing the scanning state of a laser beam.

FIG. 9 Block diagram showing an embodiment of this invention.

FIG. 10 Explanatory drawing showing the scanning state of a laser beam.

FIG. 11 Explanatory drawing showing an image coordinate system.

FIG. 12 Flowchart showing car recognition procedures using image processing.

Symbols

1	Stereoscopic camera
1a	View field
11, 12	CCD camera
13	Body
2	Laser radar
2a	Laser beam
3	Throttle actuator
31	Deflection part
32	Throttle command part
4	Brake actuator
5	Operating switch and information display part
61	Image processing part
61a	Vehicle recognition part
61b	Lane recognition part
61c	Inter-vehicle distance recognition part
62	Target following vehicle recognition part
63	Settings command part
64	Processing area settings part
7	Speed sensor
7a	Steering wheel angle sensor
7b	Brake switch
7c	Brake pedal switch
7d	Accelerator pedal switch

FIG. 1

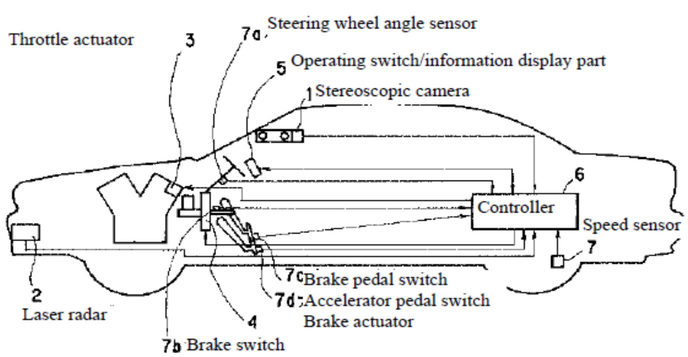


FIG. 2

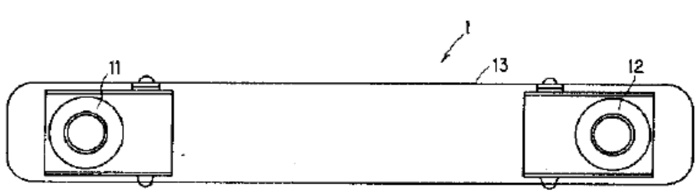
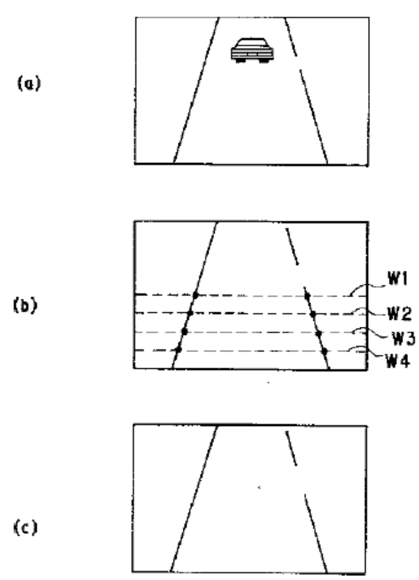


FIG. 3



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