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(54) Title: APPARATUS AND METHOD FOR RESPONDING TO A TARGET VEHICLE IN A LATERAL POSITION

(57) Abstract: A controller for a driver assistance system (10) comprises an output for transmitting a braking control signal and control logic. The control logic is capable of identifying a target vehicle (32), determining an intervention zone and determining an edge zone. The controller will transmit the braking control signal to request activation of the brakes on the host vehicle in response to the edge zone being equal to or less than zero and the target vehicle being within the intervention zone.

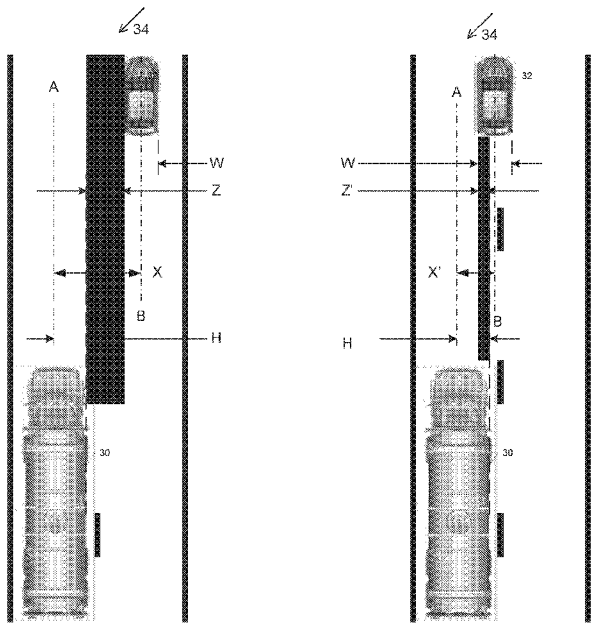

Fig. 2A Fig. 2B

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[Continued on next page]

Declarations under Rule 4.17:
- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
- *of inventorship (Rule 4.17(iv))*

Published:
- *with international search report (Art. 21(3))*
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APPARATUS AND METHOD FOR RESPONDING TO A TARGET VEHICLE IN A LATERAL POSITION

Background

[0001] The present invention relates to embodiments of a driver assistance system that responds to a target vehicle moving laterally with respect to a host vehicle. Today's driver assistance systems identify target vehicles in front of or to the side of the host vehicle. Safe longitudinal and lateral distances between the host vehicle and the target vehicle are typically predefined. If the calculated distance between the host vehicle and the target vehicle is less than the predefined distance, an automated braking action will engage to mitigate a collision. If a calculated distance to a target vehicle becomes greater than the predefined safe lateral distance, the automatic braking action may disengage. However, varying actual widths of a target vehicle may cause the braking system to automatically engage or disengage at inappropriate times. Therefore, an improvement to a system for responding to a target vehicle in a lateral position is desired.

Summary

[0002] Various embodiments of a controller for a driver assistance system comprise an output for transmitting a braking control signal and control logic. The control logic is capable of identifying a target vehicle; determining an intervention zone; determining an edge zone and transmitting the braking control signal to request activation of the brakes on the host vehicle in response to the edge zone being equal to or less than zero and the target vehicle being within the intervention zone.

[0003] In accordance with another aspect, various embodiments of a driver assistance system comprise a radar controller for identifying a target vehicle and a camera controller for identifying the target vehicle and for determining a width of the target vehicle. At least one of the radar controller and the camera controller is capable of determining an edge zone as a function of the width of the target vehicle and a width of a host vehicle, determining an

intervention zone between the target vehicle and the host vehicle, and transmitting a braking control signal in response to the edge zone being less than or equal to zero and the target vehicle being within an intervention zone.

[0004] In accordance with yet another aspect, various embodiments of a method for controlling a host vehicle having a driver assistance system comprise identifying a target vehicle in response to a video signal and a radar signal; determining a width of the target vehicle; determining an edge zone as a function of the width of the target vehicle and a width of a host vehicle; determining an intervention zone between the target vehicle and the host vehicle, and activating the service brakes on the host vehicle in response to the target vehicle being within the edge zone and within the intervention zone.

Brief Description of the Drawings

[0005] In the accompanying drawings which are incorporated in and constitute a part of the specification, embodiments of the invention are illustrated, which, together with a general description of the invention given above, and the detailed description given below, serve to exemplify the embodiments of this invention.

[0006] **FIGURE 1** illustrates an automated braking system according to one example of the present invention.

[0007] **FIGURES 2A, 2B** illustrate a roadway having a host vehicle equipped with the automated braking system of Figure 1 and a target vehicle.

[0008] **FIGURE 3** illustrates a method of detecting and responding to a target vehicle in a lateral position.

Detailed Description

[0009] **FIGURE 1** illustrates a driver assistance system (DAS) **10** for a commercial vehicle. The DAS **10** may be a Bendix ® Wingman® Fusion ™ system available from Bendix Commercial Vehicle Systems LLC of Elyria, Ohio.

[0010] The DAS **10** includes a radar controller **14**. The radar controller **14** is mounted on the lower front of a host vehicle, typically proximate to the bumper. The radar controller **14** is programmed by the vehicle manufacturer with the distance from the radar controller **14** mounting location to the centerline of the host vehicle. The radar controller **14** transmits and receives radar signals, which are electromagnetic waves used to detect an object's presence, longitudinal distance, lateral distance, speed and direction with respect to the host vehicle. The radar controller **14** can detect multiple stationary or moving objects within a wide range to the front and sides of the host vehicle.

[0011] The radar controller **14** includes a processor with control logic **20** for receiving and transmitting messages to control the DAS **10**. The control logic **20** may include volatile, non-volatile memory, solid state memory, flash memory, random-access memory (RAM), read-only memory (ROM), electronic erasable programmable read-only memory (EEPROM), variants of the foregoing memory types, combinations thereof, and/or any other type(s) of memory suitable for providing the described functionality and/or storing computer-executable instructions for execution by the control logic **20**.

[0012] The control logic **20** may determine the center of an object using the radar signals. The control logic **20** may also determine an intervention zone, where a threat of a possible collision with the object exists due to the longitudinal distance, lateral distance and relative velocity of the object with respect to the host vehicle. The control logic **20** may also determine an edge zone based on the lateral offset of the detected object from the host vehicle and the host vehicle size.

[0013] The DAS **10** includes at least one camera controller **16**. The camera controller **16** is mounted on the upper front of the host vehicle, typically proximate to the top of the windshield. The location of the camera controller **16** on the host vehicle is programmed by the vehicle manufacturer as the measurement from the mounting location of the camera controller **16** to the right front wheel edge and left front wheel edge of the host vehicle. The camera controller **16** is also programmed by the vehicle manufacturer with the distance from the camera controller **16** to the centerline of the host vehicle. This mounting location information is used to determine the host vehicle width. The camera controller **16** uses video signals to detect an object's presence, size, longitudinal distance and lateral distance with respect to the host vehicle. The camera controller **16** can detect multiple stationary or moving objects within a wide range to the front and sides of the host vehicle. The video signal from the camera controller **16** can be used to determine the width of a detected object.

[0014] The DAS **10** includes a proprietary vehicle communications bus **26** for communications between the radar controller **14** and the camera controller **16.** The control logic **20** is capable of receiving the video signals from the camera controller **16** on the proprietary communications bus **26.** The video signals may also include the width of the detected object. The radar controller **14** may also transmit the radar signals on the proprietary communications bus **26.** The information from the radar signals and video signals is used by the control logic **20** to determine the lateral offset of the detected object from the host vehicle.

[0015] The DAS **10** may include a display **18** in the cab of the host vehicle. The display **18** may show the distance of the host vehicle from the detected object and a preprogrammed following distance. The display **18** may show the status of the DAS **10** or other systems on the host vehicle.

[0016] The DAS **10** includes a braking system controller **12**. The braking system controller **12** receives braking control signals and controls the service brakes of the host vehicle. The braking system controller **12** includes an output for communicating with at least one brake control device **24**. The brake control device **24** may be an electro-pneumatic device that provides air to the service brakes on a wheel end in response to control signals from the braking system controller **12**.

[0017] The DAS **10** also communicates using a public vehicle communications bus **22** connected to the radar controller **14,** the camera controller **16,** the display **18,** the braking system controller **12** and other controllers on the vehicle. The radar controller **14** may transmit a braking control signal on the public vehicle communications bus **22** to the braking system controller **12.** The radar controller **14** can also transmit a braking activity indicator, a distance to the detected object and a status signal to the display **18.**

[0018] In another example, the camera controller **16,** the braking system controller **12** or another stand alone controller may include control logic having the functionality to receive the video signals and the radar signals. That controller would then make the determination of the lateral offset of the detected object from the host vehicle from the received information.

[0019] Therefore, a controller for a driver assistance system comprises an output for transmitting a braking control signal and control logic. The control logic is capable of identifying a target vehicle; determining an intervention zone; determining an edge zone and transmitting the braking control signal to request activation of the brakes on the host vehicle in response to the edge zone being equal to or less than zero and the target vehicle being within the intervention zone.

[0020] A driver assistance system comprises a radar controller for identifying a target vehicle and a camera controller for identifying the target vehicle and for determining a width of the target vehicle. At least one of the radar controller and the camera controller is capable of determining an edge zone as a function of the width of the target vehicle and a width of a host vehicle, determining an intervention zone between the target vehicle and the host vehicle, and transmitting a braking control signal in response to the edge zone being less than or equal to zero and the target vehicle being within an intervention zone.

[0021] **FIGURE 2A** illustrates a two lane roadway **34** having a host vehicle **30,** equipped with the DAS **10,** and a target vehicle **32**. The host vehicle **30** and the target vehicle **32** are traveling in the same direction on the roadway **34**.

[0022] In this example, the radar controller **14** and/or the camera controller **16** detects the target vehicle **32** according to the known operation of the DAS **10**. The radar controller **14** determines the longitudinal distance between the host vehicle **30** and the target vehicle **32**. The radar controller **14** determines if the target vehicle **32** is within an intervention zone. The intervention zone can be determined using different methods, such as the relative velocity between the host vehicle **30** and the target vehicle **32** is above a predetermined level, a time to collision is less than a predetermined time, a longitudinal distance is less than a predetermined distance or any combination of these factors.

[0023] The control logic **20** determines an Edge Zone Value **Z**. The control logic **20** receives a Wheel Edge Value **H** from the camera controller **16**. Wheel Edge Value **H** is the distance from the right wheel edge to the Centerline **A** of the host vehicle **30** if a target vehicle is traveling to the right side of the host vehicle. Wheel Edge Value **H** is the distance from the left wheel edge to the Centerline **A** of the host vehicle if the target vehicle is traveling to the left side of the host vehicle. Centerline **A** is known due to the programmed mounting location of the camera controller **16**. In one example, a width of the host vehicle **30** is about 2.4 meters. Assuming the camera controller **16** is mounted in the center of the host vehicle, the known Wheel Edge Value **H** is then about 1.2m from the mounting location of the camera controller **16.**

[0024] The camera controller **16** determines the Width **W** of the target vehicle **32** from the video signals. In one example, the Width **W** of the target vehicle **32** is determined to be about 1.8m. From the Width **W**, the Centerline **B** of the target vehicle **32** is determined. The Centerline **B** is about 0.9m from the edge of the target vehicle **32**. The control logic **20** then determines a Lateral Offset Value **X** of the target vehicle **32** from the host vehicle **30**. The Lateral Offset Value **X** is determined from the known Centerline **A** of the host vehicle **30** to the determined Centerline **B** of the target vehicle **32**. In this example, Lateral Offset Value **X** is determined to be 3.1m.

[0025] The Edge Zone Value **Z** is then calculated as the absolute value of Lateral Offset Value **X** minus the Width **W** of the target vehicle **32** divided by 2 minus the absolute value of the Wheel Edge Value **H**. The absolute value is used because the target vehicle **32** may be either to the right forward edge of the host vehicle **30** or to the left forward edge of the host vehicle **30**. The formula for the Edge Zone Value **Z** is expressed below:

[0026] $$Z = \left\{|X| - \frac{W}{2} - |H|\right\}$$

[0027] For the example shown in Fig. 2A, the Edge Zone Value **Z** is 1.0m and is therefore greater than zero. As long as this Edge Zone Value **Z** is greater than zero, the DAS **10** proceeds to operate as normal by continuing to monitor the target vehicle **32** and determine if the target vehicle **32** is within the intervention zone. The Edge Zone Value **Z** is also continually re-calculated as long as the target vehicle **32** is within the field of view of the radar controller **14** and/or the camera controller **16**.

[0028] **FIGURE 2B** illustrates the same two lane roadway **34** having the host vehicle **30** and the target vehicle **32** traveling in the same direction. In Fig. 2B however, the target vehicle **32** has shifted its lateral position, as if moving into the same lane of travel as the host vehicle **30**. The Width **W** of the target vehicle **32** and the Wheel Edge Value **H** of the host vehicle **30** remain the same. However, the DAS **10** calculates a new Edge Zone Value **Z'** because the Lateral Offset Value **X'** has changed with respect to the target vehicle **32**. In the example shown in Fig. 2B, the Edge Zone Value **Z'** is less than zero because the Lateral Offset Value **X'** has decreased. As long as the target vehicle **32** is in the intervention zone, the DAS **10** will intervene with automated braking to mitigate a collision.

[0029] **FIGURE 3** illustrates a method **40** of responding to a target vehicle in a lateral position according to an example of the present invention. In step **42**, the camera controller **16** is configured with the Wheel Edge Value **H** of the host vehicle **30**. This Wheel Edge Value **H** is programmed at the vehicle manufacturer when the camera controller **16** is installed. In this example, the Wheel Edge Value **H** is the distance from the camera controller **16** to the right front wheel end edge of the host vehicle **30**.

[0030] In step **44**, the radar controller **14** is configured by the vehicle manufacturer with the distance from the radar controller **14** mounting location to the Centerline **A** of the host vehicle **30**. The camera controller **16** is configured by the vehicle manufacturer with the distance from the camera controller **16** mounting location to the Centerline **A** of the host vehicle **30**. Both the radar controller **14** and the camera controller **16** are mounted generally along the Centerline **A** of the host vehicle **30**.

[0031] During vehicle operation, the radar controller **14** and camera controller **16** will scan for an object, such as target vehicle **32,** using known algorithms. In step **46,** it is determined whether the radar controller **14** and/or the camera controller **16** have detected a target vehicle. Target vehicles may be detected to the left, right or center of the lane of travel of the host vehicle **30.** If no target vehicle is detected, the method **40** remains at step **46**.

[0032] In step **48,** when a target vehicle **32** is detected, the camera controller **16** determines the Width **W** of the target vehicle. If multiple target vehicles are detected, the data is collected for each target vehicle. The control logic **20** receives the width of the target vehicle **32** from the camera controller **16.** The control logic **20** uses the width to learn the approximate Centerline **B** of the target vehicle **32**. From this information, the control logic **20** determines the Lateral Offset Value **X** from the Centerline **A** of the host vehicle **30** to the Centerline **B** of the target vehicle **32** in step **50.**

[0033] In step **52**, the control logic **20** determines if the target vehicle **32** is within an intervention zone. The intervention zone is an area wherein a threat of a possible collision with the target vehicle **32** exists due to the longitudinal distance, lateral distance and relative velocity of the target vehicle **32** with respect to the host vehicle **30**. In one example, the radar controller **14** and camera controller **16** work together to determine the intervention zone. The intervention zone is determined in a known manner. If the target vehicle **32** is outside of the intervention zone, the method **40** proceeds to step **54** where the target vehicle **32** continues to be monitored. The method **40** then returns to step **48** to determine the Width **W** and the Lateral Vehicle Offset **X**.

[0034] If the target vehicle **32** is within the intervention zone, the method **40** proceeds to step **56**. The control logic **20** calculates the Edge Zone Value **Z** by subtracting half of the Width **W** of the target vehicle **32** and the absolute value of the Wheel Edge Value **H** of the host vehicle **30** from the absolute value of the Lateral Offset Value **X**. Alternatively, the Edge Zone Value **Z** may be calculated continually even if the target vehicle **32** is outside of the intervention zone.

[0035] In step **58**, the control logic **20** determines if the Edge Zone Value **Z** is less than or equal to zero. If the Edge Zone Value **Z** is greater than zero, the method **40** proceeds to step **60**. In step **60**, the control logic **20** determines that collision mitigation in the form of automated braking is not required. The control logic **20** will not transmit, or will stop transmitting, a braking control signal. The method **40** then continues to step **64** where the target vehicle **32** continues to be monitored.

[0036] If the Edge Zone Value **Z** is less than or equal to zero, or the target vehicle **32** is within the edge zone, the control logic **20** will transmit a braking control signal on the vehicle communications bus **22** in step **62.** The braking system controller **12** receives the braking control signal and will activate or continue to activate the braking control device **24** to mitigate any possible collision with the target vehicle **32**. The braking control device **24** is connected to the service brakes of the host vehicle **30.** The control logic **20** may also transmit a signal on the vehicle communications bus **22** indicating the transmission of the braking control signal. The display **18** may also indicate the braking intervention to the driver of the host vehicle **30** when the display **18** receives an indicator signal from the control logic **20.**

[0037] In another example, the Edge Zone Value **Z** may be compared to a value slightly greater than zero to ensure that there is ample lateral distance between the target vehicle **32** and the host vehicle **30.**

[0038] The method **40** then continues to step **64** where the target vehicle continues to be monitored. Step **64** returns the method **40** to step **52.**

[0039] Therefore, a method for controlling a host vehicle having a driver assistance system comprise identifying a target vehicle in response to a video signal and a radar signal; determining a width of the target vehicle; determining an edge zone as a function of the width of the target vehicle and a width of a host vehicle; determining an intervention zone between the target vehicle and the host vehicle, and activating the service brakes on the host vehicle in response to the target vehicle being within the edge zone and within the intervention zone.

[0040] This inventive controller and method are preferable to a prior art system of setting a predefined lateral offset based solely on a centerline of the host vehicle and a target vehicle. The method herein defined will minimize a collision between a target vehicle and a host vehicle since the width of the target vehicle is accurately estimated and braking can intervene sooner as required if the target vehicle is overlapping the travel path of the host vehicle. The control logic for performing the method can be located in the radar controller, the camera controller, the braking system controller or another stand alone controller on the host vehicle.

[0041] While the present invention has been illustrated by the description of embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention, in its broader aspects, is not limited to the specific details, the representative apparatus, and illustrative examples shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

We claim:

1. A controller for a driver assistance system on a host vehicle comprising:

an output for transmitting a braking control signal; and

control logic, the control logic capable of:

identifying a target vehicle;

determining an intervention zone between the host vehicle and the target vehicle;

determining an edge zone between the host vehicle and the target vehicle; and

transmitting the braking control signal to request activation of the brakes on the host vehicle in response to the edge zone being equal to or less than zero and the target vehicle being within the intervention zone.

2. The controller as in claim 1, further comprising an input for receiving a video signal; wherein the control logic is further capable of receiving a width of the target vehicle at the input for receiving the video signal.

3. The controller as in claim 2, wherein the edge zone is a function of a host vehicle width and the target vehicle width.

4. The controller as in claim 3, wherein the host vehicle width is based on the distance from a wheel edge of the host vehicle to a mounting location of the controller.

5. The controller as in claim 4, wherein the mounting location of the controller on the host vehicle is programmed into the control logic.

6. The controller as in claim 1, wherein the controller includes a radar for identifying the target vehicle.

7. The controller as in claim 6, further comprising an input for receiving a video signal; wherein the control logic is further capable of determining the intervention zone by using the radar and the video signal.

8. The controller as in claim 1, further comprising an output for transmitting a status signal, wherein the status signal is indicative of the braking control signal status.

9. A driver assistance system comprising:

a radar controller for identifying a target vehicle;

a camera controller for identifying the target vehicle and for determining a width of the target vehicle;

wherein at least one of the radar controller and the camera controller is capable of:

determining an edge zone as a function of the width of the target vehicle and a width of a host vehicle;

determining an intervention zone between the target vehicle and the host vehicle; and

transmitting a braking control signal in response to the edge zone being less than or equal to zero and the target vehicle being within the intervention zone.

10. The driver assistance system as in claim 9, further comprising: a braking controller for receiving the braking control signal and activating the service brakes in response to the braking control signal.

11. The driver assistance system as in claim 10, wherein the radar controller and the camera controller communicate using a proprietary communication bus and the radar controller and camera controller communicate with the braking controller using a vehicle communications bus.

12. The driver assistance system as in claim 9, further comprising a display for indicating the presence of the target vehicle in the intervention zone and a status of the braking control signal.

13. A method for controlling a host vehicle having a driver assistance system comprising:

identifying a target vehicle in response to a video signal and a radar signal;

determining a width of the target vehicle;

determining an edge zone as a function of the width of the target vehicle and a width of a host vehicle;

determining an intervention zone between the target vehicle and the host vehicle; and

activating the service brakes on the host vehicle in response to the target vehicle being within the edge zone and the target vehicle being within the intervention zone.

14. The method as in claim 13, further comprising: programming the driver assistance system with a width of the host vehicle.

15. The method as in claim 13, wherein determining the width of the target vehicle comprises using the video signal.

16. The method as in claim 13, further comprising releasing the service brakes in response to the target vehicle exiting the edge zone.

17. The method as in claim 13, wherein determining the intervention zone comprises using both the video signal and the radar signal.

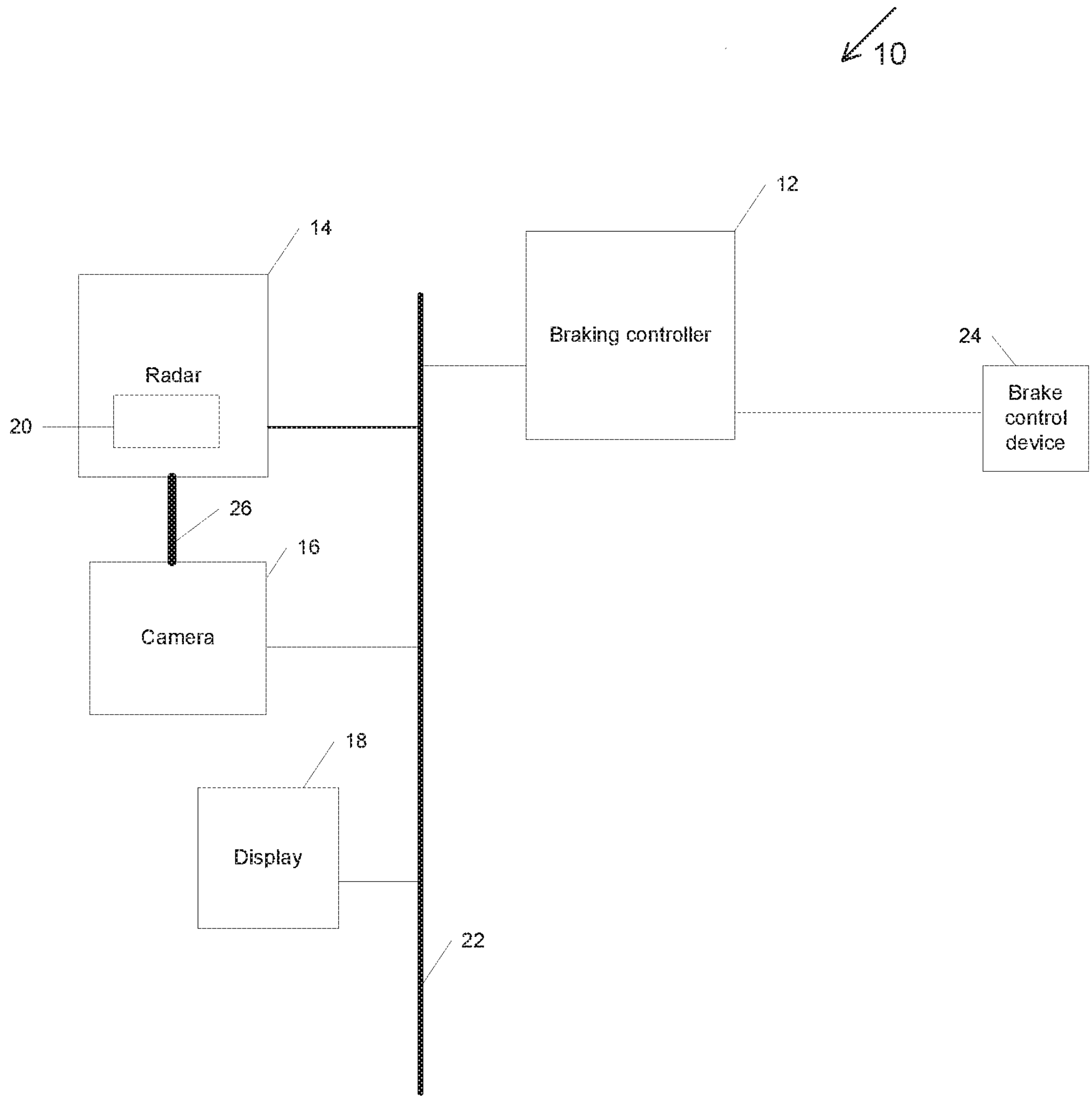
10
12
14
Braking controller
24
Radar
Brake
control
device
20
26
16
Camera
18
Display
22

Fig. 1

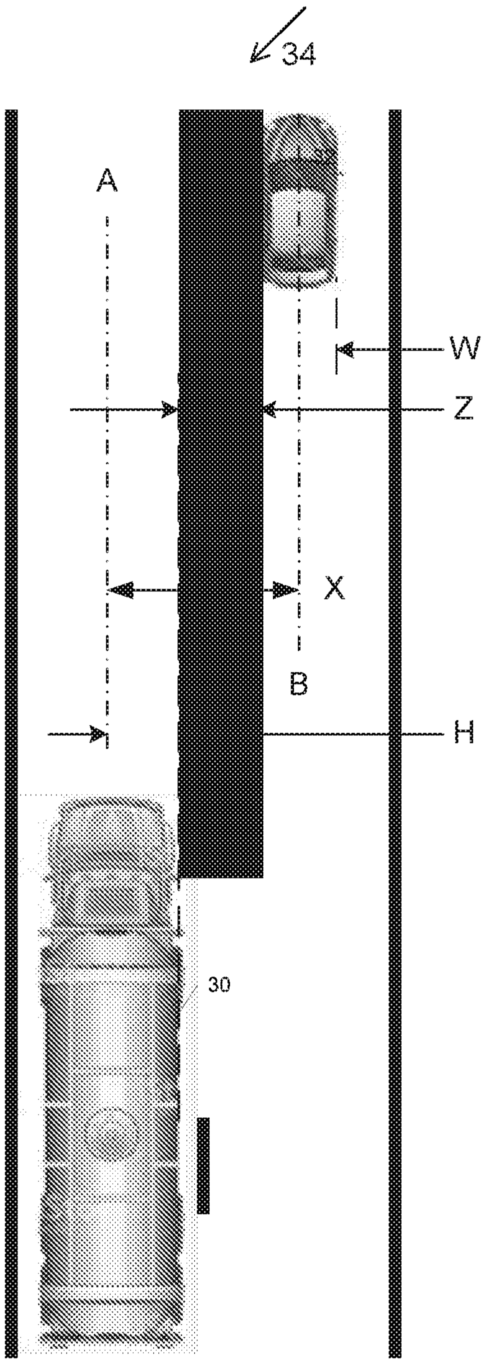

Fig. 2A

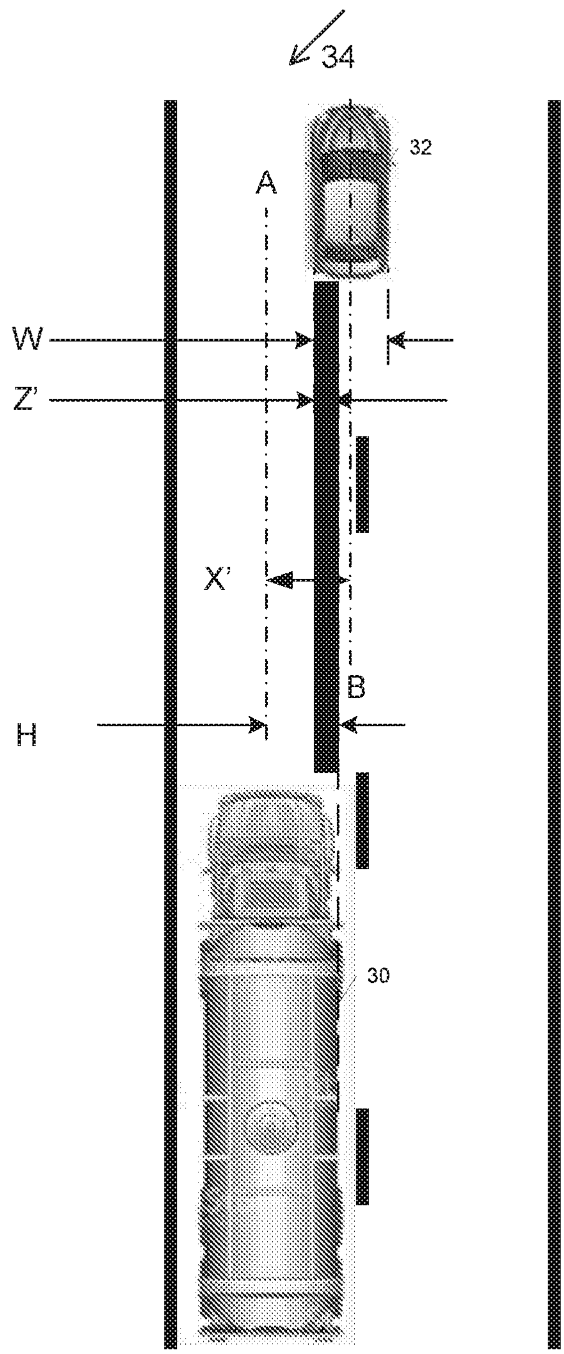

Fig. 2B

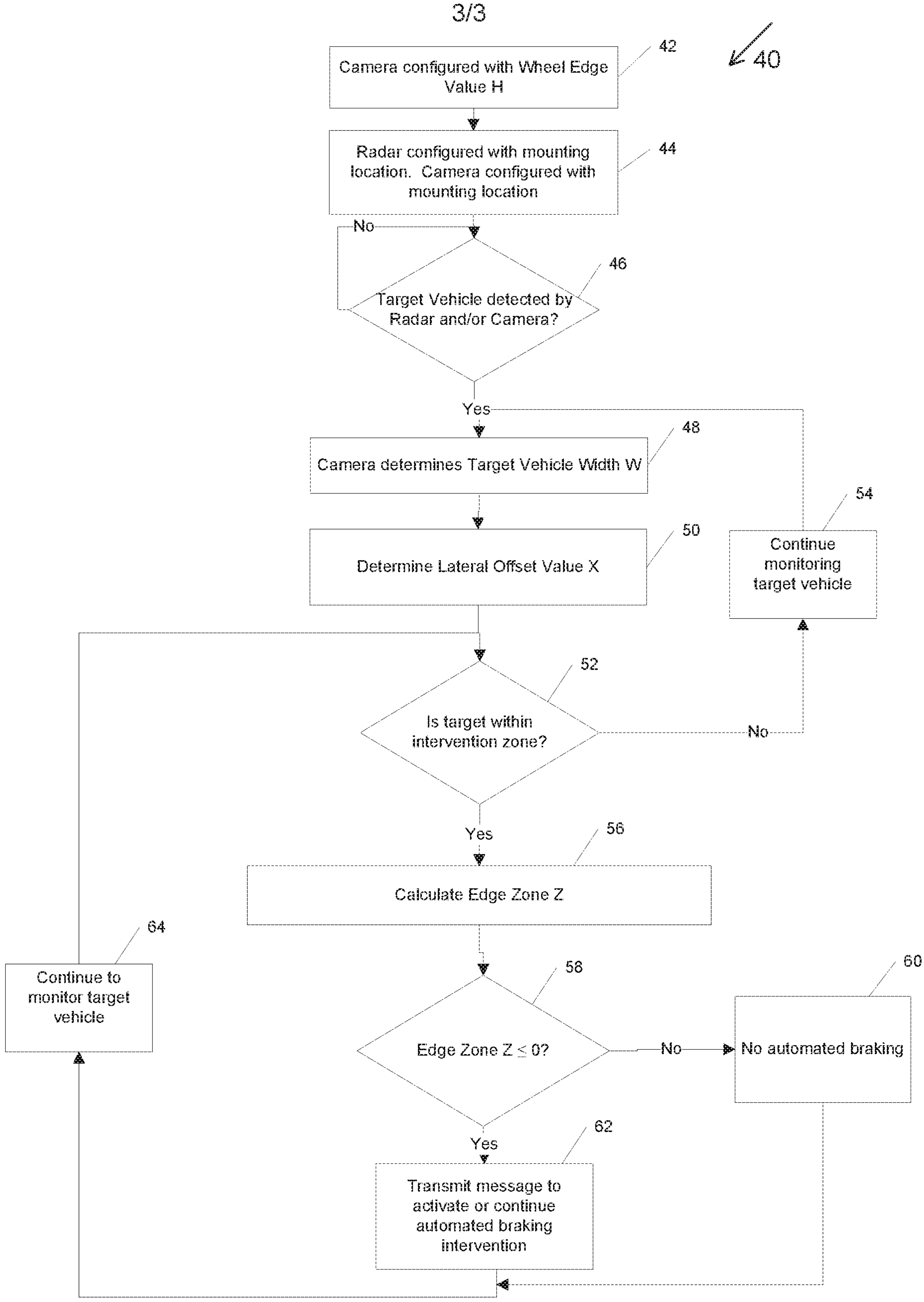
40
Camera configured with Wheel Edge Value H
42
Radar configured with mounting location. Camera configured with mounting location
44
No
Target Vehicle detected by Radar and/or Camera?
46
Yes
Camera determines Target Vehicle Width W
48
Determine Lateral Offset Value X
50
Continue monitoring target vehicle
54
Is target within intervention zone?
52
No
Yes
Calculate Edge Zone Z
56
Continue to monitor target vehicle
64
Edge Zone Z ≤ 0?
58
No
No automated braking
60
Yes
Transmit message to activate or continue automated braking intervention
62

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/013307

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60T7/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60T B60W B60K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2012/152896 A1 (JAGUAR CARS [GB]; CUND MARK [GB]) 15 November 2012 (2012-11-15)	1,6,8
Y	page 12, lines 11-26	2-5,7, 9-17

Y	EP 2 803 546 A1 (DENSO CORP [JP]) 19 November 2014 (2014-11-19) paragraphs [0010] - [0018], [0044], [0045], [0048] - [0051]	2-5,7, 9-17

X	JP 2005 028992 A (TOYOTA MOTOR CORP) 3 February 2005 (2005-02-03) abstract pages 76-79	1-17

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
11 May 2018	25/05/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Nielles, Daniel

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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