FIG. 1

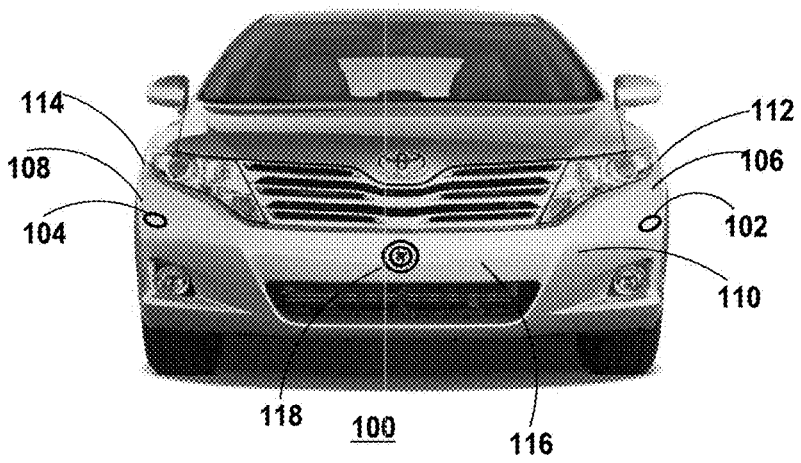
114
108
104
112
106
102
110
118
100
116

FIG. 3

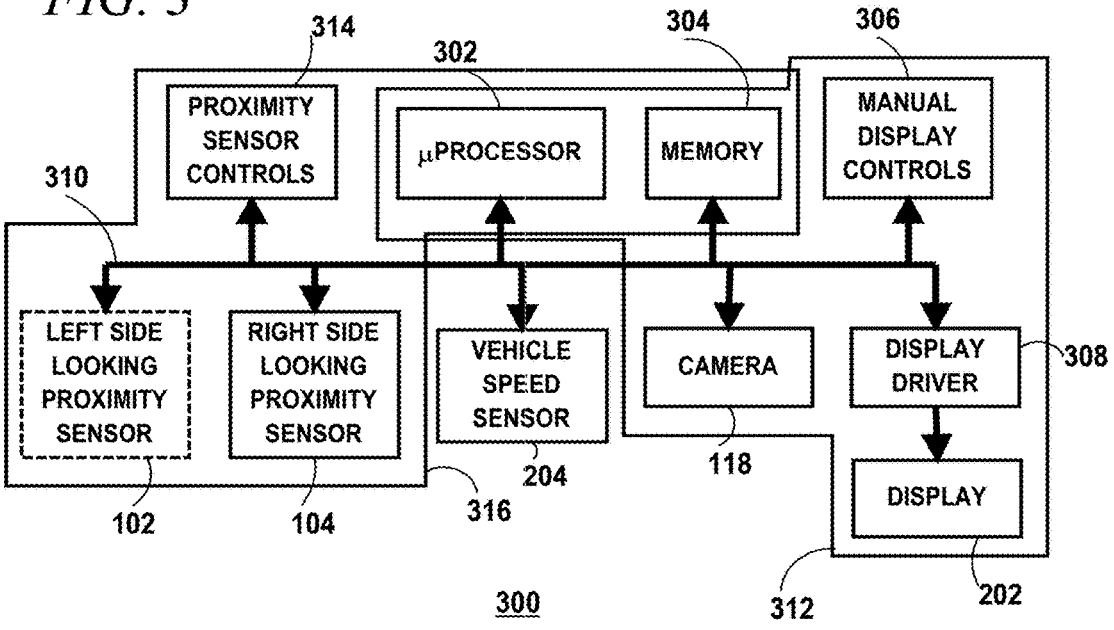
314
302
304
306
PROXIMITY SENSOR CONTROLS
µPROCESSOR
MEMORY
MANUAL DISPLAY CONTROLS
310
LEFT SIDE LOOKING PROXIMITY SENSOR
RIGHT SIDE LOOKING PROXIMITY SENSOR
VEHICLE SPEED SENSOR
CAMERA
DISPLAY DRIVER
308
DISPLAY
102
104
316
204
118
312
202
300

FIG. 4

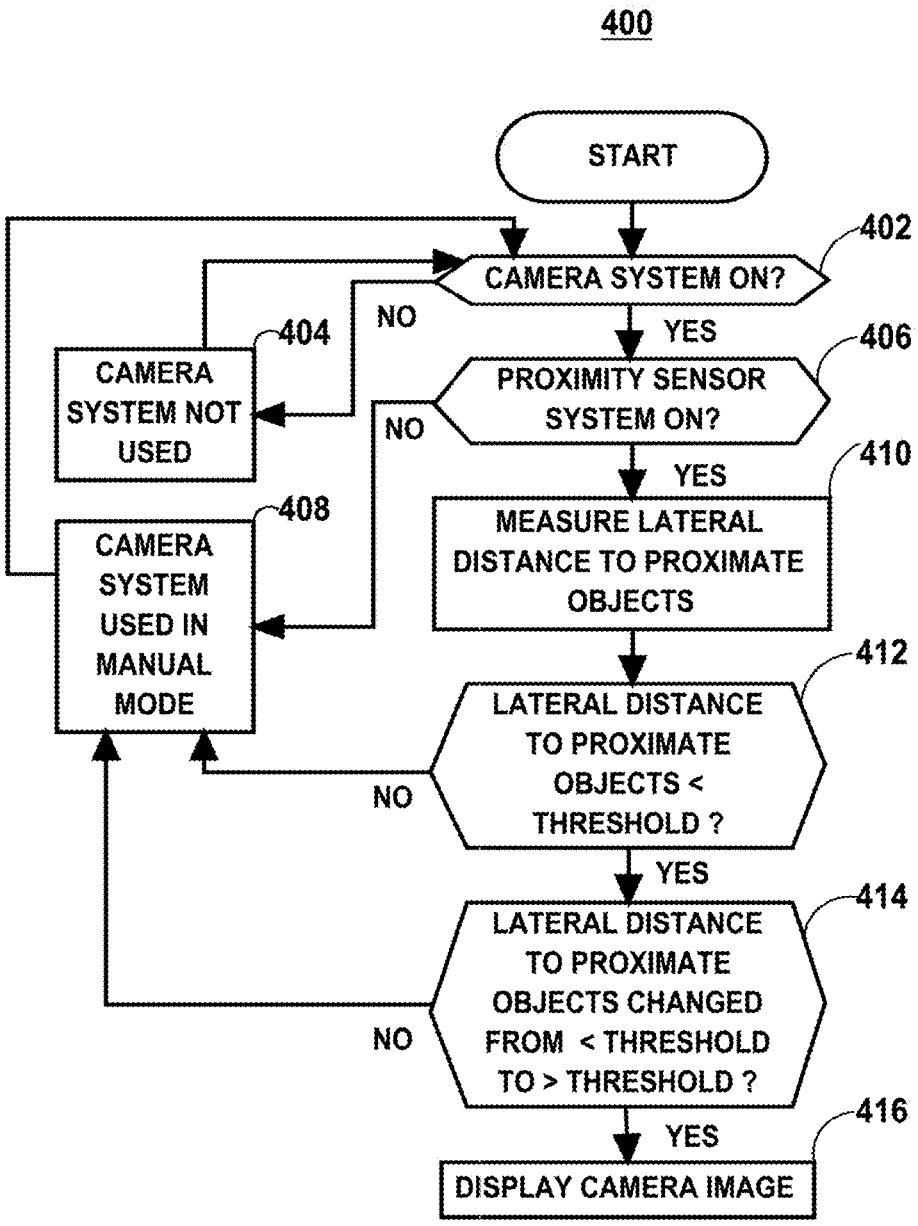
400
START
CAMERA SYSTEM ON?
402
NO
YES
CAMERA SYSTEM NOT USED
404
PROXIMITY SENSOR SYSTEM ON?
406
NO
YES
CAMERA SYSTEM USED IN MANUAL MODE
408
MEASURE LATERAL DISTANCE TO PROXIMATE OBJECTS
410
LATERAL DISTANCE TO PROXIMATE OBJECTS < THRESHOLD ?
412
NO
YES
LATERAL DISTANCE TO PROXIMATE OBJECTS CHANGED FROM < THRESHOLD TO > THRESHOLD ?
414
NO
YES
DISPLAY CAMERA IMAGE
416

FIG. 5

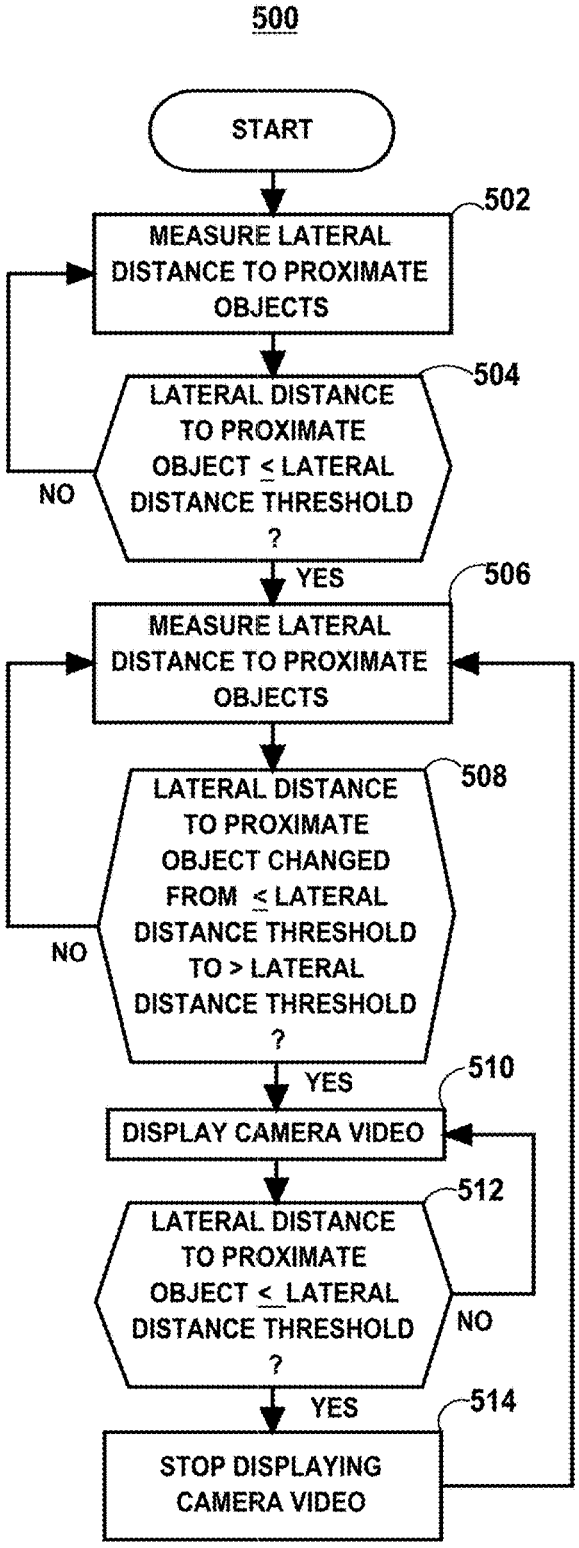
500
START
502
MEASURE LATERAL DISTANCE TO PROXIMATE OBJECTS
504
LATERAL DISTANCE TO PROXIMATE OBJECT ≤ LATERAL DISTANCE THRESHOLD ?
NO
YES
506
MEASURE LATERAL DISTANCE TO PROXIMATE OBJECTS
508
LATERAL DISTANCE TO PROXIMATE OBJECT CHANGED FROM ≤ LATERAL DISTANCE THRESHOLD TO > LATERAL DISTANCE THRESHOLD ?
NO
YES
510
DISPLAY CAMERA VIDEO
512
LATERAL DISTANCE TO PROXIMATE OBJECT ≤ LATERAL DISTANCE THRESHOLD ?
NO
YES
514
STOP DISPLAYING CAMERA VIDEO

FIG. 14

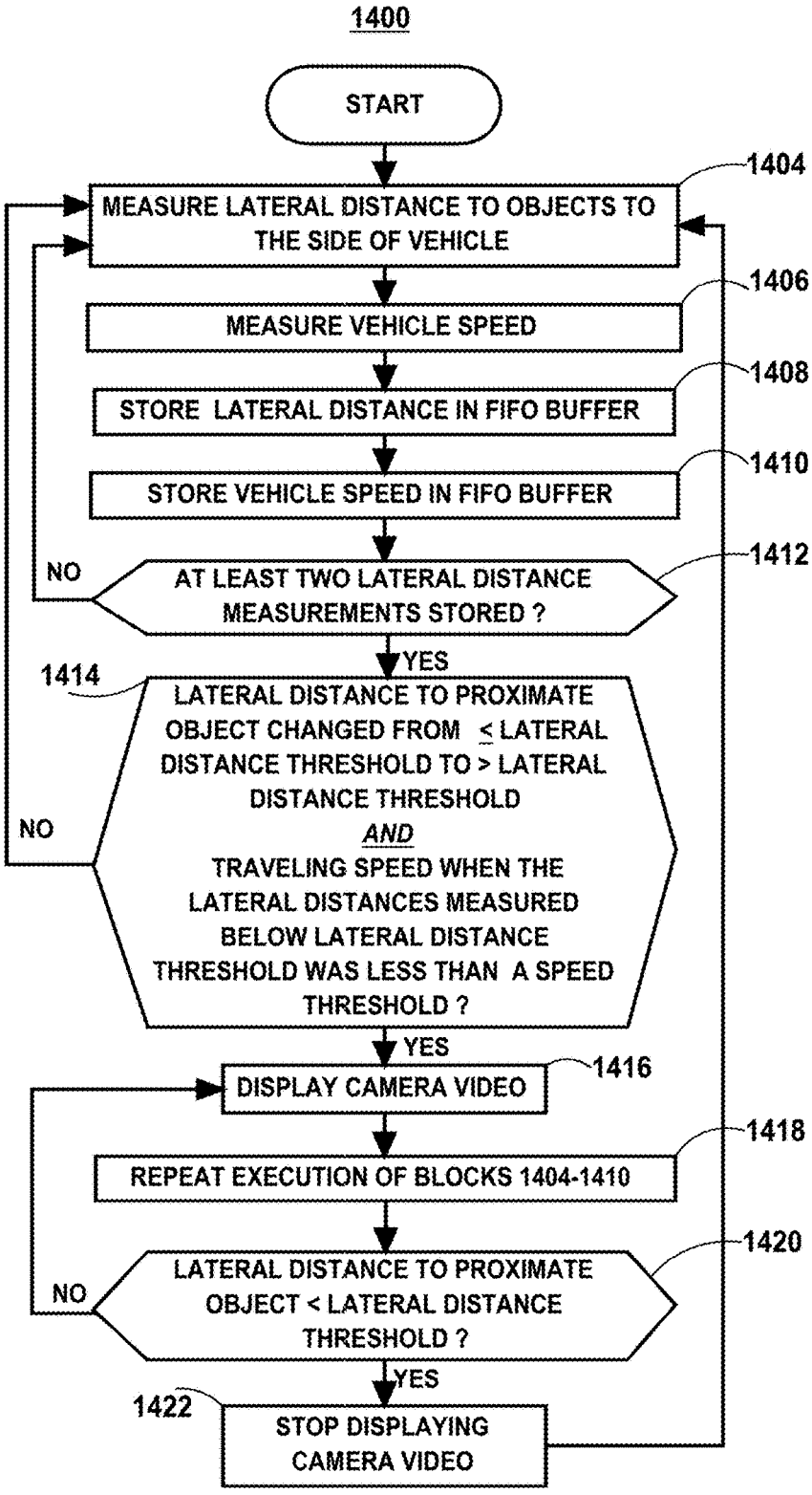
1400
START
1404
MEASURE LATERAL DISTANCE TO OBJECTS TO THE SIDE OF VEHICLE
1406
MEASURE VEHICLE SPEED
1408
STORE LATERAL DISTANCE IN FIFO BUFFER
1410
STORE VEHICLE SPEED IN FIFO BUFFER
1412
NO
AT LEAST TWO LATERAL DISTANCE MEASUREMENTS STORED ?
YES
1414
LATERAL DISTANCE TO PROXIMATE OBJECT CHANGED FROM ≤ LATERAL DISTANCE THRESHOLD TO > LATERAL DISTANCE THRESHOLD
AND
TRAVELING SPEED WHEN THE LATERAL DISTANCES MEASURED BELOW LATERAL DISTANCE THRESHOLD WAS LESS THAN A SPEED THRESHOLD ?
NO
YES
1416
DISPLAY CAMERA VIDEO
1418
REPEAT EXECUTION OF BLOCKS 1404-1410
1420
NO
LATERAL DISTANCE TO PROXIMATE OBJECT < LATERAL DISTANCE THRESHOLD ?
YES
1422
STOP DISPLAYING CAMERA VIDEO

FIG. 18

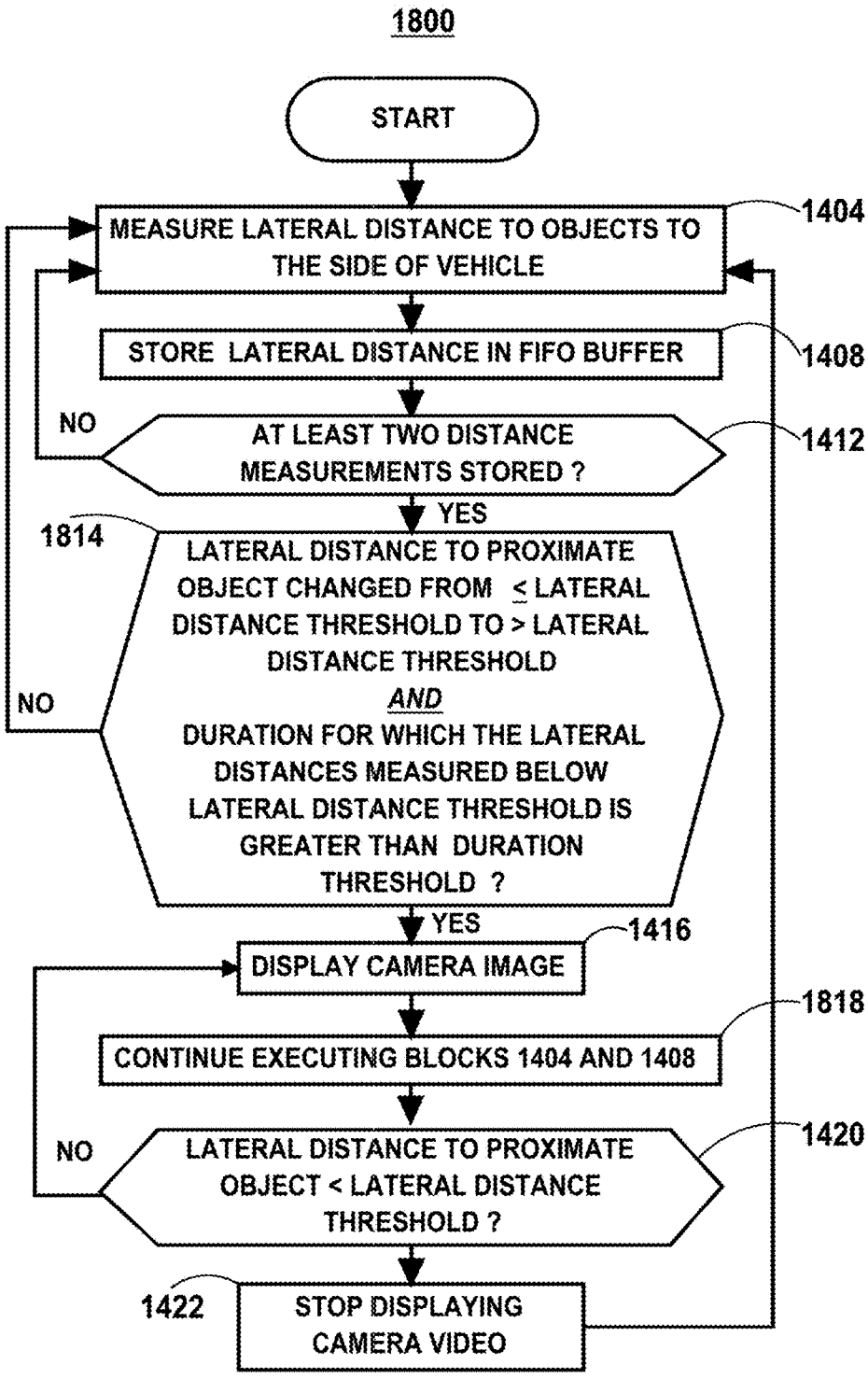
1800
START
MEASURE LATERAL DISTANCE TO OBJECTS TO THE SIDE OF VEHICLE
1404
STORE LATERAL DISTANCE IN FIFO BUFFER
1408
NO
AT LEAST TWO DISTANCE MEASUREMENTS STORED ?
1412
YES
1814
LATERAL DISTANCE TO PROXIMATE OBJECT CHANGED FROM ≤ LATERAL DISTANCE THRESHOLD TO > LATERAL DISTANCE THRESHOLD
AND
DURATION FOR WHICH THE LATERAL DISTANCES MEASURED BELOW LATERAL DISTANCE THRESHOLD IS GREATER THAN DURATION THRESHOLD ?
NO
YES
1416
DISPLAY CAMERA IMAGE
1818
CONTINUE EXECUTING BLOCKS 1404 AND 1408
1420
NO
LATERAL DISTANCE TO PROXIMATE OBJECT < LATERAL DISTANCE THRESHOLD ?
1422
STOP DISPLAYING CAMERA VIDEO

FIG. 21

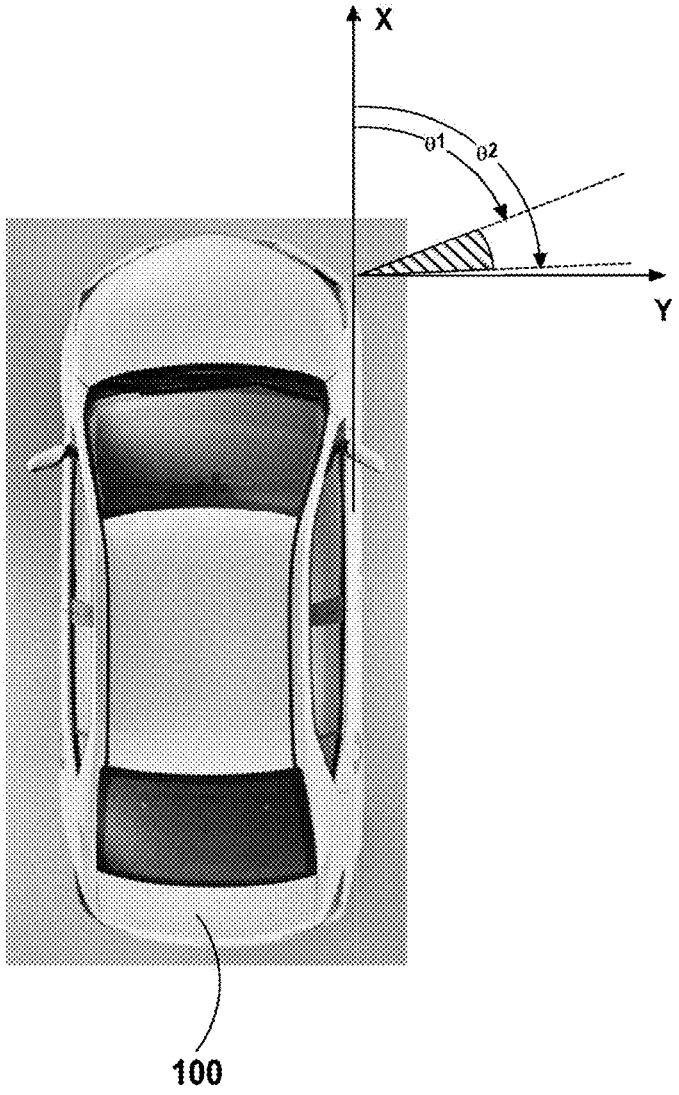

FIG. **10** is a third schematic representation of a driving environment illustrating a third scenario in which systems for controlling a camera and a display at intersections are used;

FIG. **11** is a graph including a plot of measured lateral distance to proximate objects versus vehicle position for the third scenario illustrated in FIG. **10**;

FIG. **12** is a fourth schematic representation of a driving environment illustrating a fourth scenario in which systems for controlling a camera and a display at intersections are used;

FIG. **13** is a graph including a plot of measured lateral distance to proximate objects versus vehicle position for the fourth scenario illustrated in FIG. **12**;

FIG. **14** is a flowchart of a third method of controlling the camera and the display of the vehicle shown in FIGS. **1-2** according to a third example provided in the present disclosure;

FIG. **15** is a table representing a first-in-first-out memory buffer of lateral distance measurements that is used in practicing the method shown in FIG. **14**;

FIG. **16** is a table representing a first-in-first-out memory buffer of vehicle speed that is used in practicing the method shown in FIG. **14**;

FIG. **17** is portion of a flowchart including an alternative condition that may be substituted into the flowchart shown in FIG. **14** according to fourth example of a method of controlling a camera and a display of a vehicle;

FIG. **18** is a flowchart of a fifth method of controlling a camera and a display of a vehicle according to a fifth example provided in the present disclosure;

FIG. **19** is a portion of a flowchart including an alternative condition that may be substituted into the flowchart shown in FIG. **18** according to a sixth example of a method of controlling a camera and a display of a vehicle;

FIG. **20** depicts a field of view for a lateral proximity sensor for the vehicle shown in FIGS. **1-2** according to a first example; and

FIG. **21** depicts a field of view for a lateral proximity sensor for the vehicle shown in FIGS. **1-2** according to a second example.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views.

FIG. **1** is a front view of a first vehicle **100** equipped with an automatic system **300** (FIG. **3**) for controlling a camera **118** and a display **202** (FIG. **2**) at traffic intersections and FIG. **2** is a top view of the first vehicle **100** shown in FIG. **1**. The first vehicle **100** includes a left (from the perspective of the driver) side looking proximity sensor **102** and a right side looking proximity sensor **104** mounted respectively in a left side **106** and a right side **108** of a front fascia **110** of the first vehicle **100**. Alternatively, the proximity sensors **102**, **104** could be mounted in a left fender **112** and a right fender **114** respectively of the first vehicle **100**. The proximity sensors **102**, **104** are suitably located forward of the front wheel opening of the first vehicle **100**, so as to be better positioned to sense an opening up the region around a front **116** of the first vehicle **100** when the first vehicle **100** reaches a traffic intersection. The camera **118** is suitably a panoramic camera and is mounted pointing forward at the center of the front fascia **110** of the first vehicle **100**.

Alternatively, multiple cameras can be used in place of the panoramic camera **118**. Image stitching can be used to combine images from multiple cameras. For example a pair of cameras including one pointed somewhat (though not necessarily exactly, for example at a 45° angle with respect to a vehicle forward direction) toward the left side of the first vehicle **100** and one pointed somewhat (though not necessarily exactly, for example at a 45° angle with respect to a vehicle forward direction) toward the right side of the first vehicle **100** can be used in lieu of a panoramic camera.

As shown in FIG. **2** the first vehicle **100** also includes a dashboard mounted display **202** which is used to display video from the camera **118**, a vehicle speed sensor **204** for sensing the speed of the first vehicle **100** and an electronic control unit (ECU) **206**. Symmetric angles α and $-\alpha$ which are measured from an X-axis that is aligned with a longitudinal axis of the first vehicle **100** indicate a horizontal field of view of the camera **118**. The vertical field of view may for example be 10-20 degrees. A pair of lines **208** extending from the left side looking proximity sensor **102** indicated an approximate field of view of the left side looking proximity sensor **102**. Similarly a pair of lines **210** extending from the right side looking proximity sensor **104** indicate an approximate field of view of the right side looking proximity sensor **104**.

According to an alternative design only one of the side looking proximity sensors **102**, **104** is used. For example in countries where vehicles are driven on the right side of the road optionally a system can include only the right side looking proximity sensor **104** and in countries where vehicles are driven on the left side of the road optionally the system **300** (FIG. **3**) can include only the left side looking proximity sensor **102**. Even if vehicles equipped with the system **300** (FIG. **3**) include both proximity sensors **102**, **104** the system **300** (FIG. **3**) may only use one.

FIG. **3** is a block diagram of the automatic system **300** for controlling the camera **118** and the display **202** that are included in the first vehicle **100** shown in FIG. **1** and FIG. **2**. The system **300** comprises a microprocessor **302**, a memory **304**, one or more manual display controls **306**, the left side looking proximity sensor **102**, the right side looking proximity sensor **104**, proximity sensor controls **314**, the vehicle speed sensor **204**, the camera **118** and a display driver **308** coupled together through a signal bus **310**. The display driver **308** is coupled to the display **202**. The microprocessor **302** executes a program stored in the memory for controlling the camera **118** and the display driver **308** and selectively coupling a video feed from the camera **118** to the display driver **308** which in turn drives the display **202** in order to display the video feed. The memory **304** is one form of non-transitory computer readable medium that may be used to store the aforementioned program. The one or more manual display controls **306** and the proximity sensor controls **314** can, for example, comprise physical buttons, or virtual GUI buttons that are actuated via a touch screen of the display **202**. The manual display controls **306** can be used to override automatic control of the a camera system **312**, which is described herein below, should a driver choose to do so. The proximity sensor controls **314** can be used to turn on and turn off the proximity sensors **102**, **104**. As shown in FIG. **3** the left side looking proximity sensor **102** is indicated as being optional which, as discussed above, is appropriate for countries in which vehicles are driven on the right side of the road. The proximity sensors **102**, **104** can, for example, comprise sonar, radar and/or lidar. The left side looking proximity sensor **102**, the right side looking proximity sensor **104**

in new lateral distance and vehicle speed measurements being stored in the FIFO buffers **1500**, **1600**. After block **1418** the method **1400** proceeds to decision block **1420** the outcome of which depends on whether the lateral distance to proximate objects, as reflected in the last lateral distance measurement, is now once again less than the lateral distance threshold. If the outcome of decision block **1420** is negative the method loops back to decision block **1416** and continues execution as described above. When the outcome of decision block **1420** is positive the method **1400** proceeds to block **1422** in which displaying of the video from the camera **118** on the display **202** is stopped. After executing block **1422** the method **1400** loops back to block **1404** and continues executing as previously described.

FIG. **15** is a table representing the first FIFO buffer **1500** which includes lateral distance measurements at a sequence of times denoted T_0, T_{-1} . . . T_{-K} . . . T_{-N} with T_0 being the most recent time. FIG. **16** is a table representing the second FIFO buffer **1600** which includes vehicle speed at the sequence of times T_0, T_{-1} . . . T_{-K} . . . T_{-N}. Note however that there can also be an offset between the times at which the lateral distance measurements are obtained and the times at which the vehicle speed measurements are obtained.

FIG. **17** is portion of a flowchart **1700** including an alternative condition that may be substituted into the flowchart shown in FIG. **14** according to fourth example of a method **1700** of controlling a camera and a display of a vehicle. Decision block **1714** shown in FIG. **17** can be used in lieu of decision block **1414** of method **1400**. Decision block **1714** tests whether the lateral distance to proximate objects changed from less than the lateral distance threshold to more than the lateral distance AND (Boolean AND) the distance travelled while the lateral distance was less than the lateral distance threshold was greater than a preprogrammed travel distance threshold. The use of the condition involving the travel distance threshold serves to avoid false triggers that could occur when the vehicle **100** being driven along a road passes a small closely spaced object, such as, for example, a mailbox positioned close to the road.

FIG. **18** is a flowchart of a fifth method **1800** of controlling the camera **118** and the display **202** of the vehicle **100** according to a fifth example provided in the present disclosure. The method **1800** includes the blocks **1404**, **1408**, **1412**, **1416**, **1420** and **1422** in common with the method **1400** shown in FIG. **14** and described above. The method **1800** does not measure vehicle speed so blocks **1406** and **1410** are not included. Decision block **1814** which takes the place of decision block **1414** tests if the lateral distance to proximate objects changed from less than the lateral distance threshold to more than the lateral distance threshold AND (Boolean AND) the duration for which the lateral distance measured below the lateral distance threshold was greater than a duration threshold. Including such duration related criteria in decision block **1814** filters out false triggers due to the vehicle passing objects positioned close to the edge of the road such as a mailbox. Block **1818** represents repetition of blocks **1404** and **1408**.

FIG. **19** is a portion of a flowchart **1900** including an alternative condition that may be substituted into the flowchart shown in FIG. **18** according to a sixth example of a method of controlling a camera and a display of a vehicle. Decision block **1914** can be used in lieu of decision block **1814**. Decision block **1914** tests if the lateral distance to objects proximate to the vehicle **100** changed from less than the lateral distance threshold to greater than the lateral distance threshold AND (Boolean AND) a turn signal (not shown) of the vehicle **100** has been activated. Alternatively a Boolean OR is used in block **1914** in lieu of the Boolean AND. Also alternatively, the status of the turn signal (not shown) and/or a brake switch (not shown) of the vehicle **100** by is used to determine if the camera **118** will display video from the camera **118**.

FIG. **20** depicts a field of view for a lateral proximity sensor (e.g., sonar, radar, LIDAR) for the vehicle **100** shown in FIGS. **1-2** according to a first example. The field of view extends a first angle θ**1** to a second angle θ**2**. θ**1** and θ**2** are measured with respect to a longitudinal axis of the vehicle **100** which is parallel to an X-axis shown in FIGS. **20-21**. θ**1** is suitably between 80° and 85° from the vehicle longitudinal axis (X-axis). θ**2** is greater than θ**1** and is suitably between 95° and 100°. In FIG. **20** θ**1** is equal to 85° and θ**2** is equal to 95°. According to certain embodiments the horizontal extent of the field of view, i.e., the difference between θ**2** and θ**1** is at least 10°. According to certain embodiments the field of view of the proximity sensor includes at least one angle in the approximate range of 75° and 85°.

FIG. **21** depicts a field of view for a lateral proximity sensor for the vehicle **100** shown in FIGS. **1-2** according to a second example. In FIG. **21** θ**1** is equal to 75° and θ**2** is equal to 88°.

Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

I claim:

1. A vehicle comprising:

a front;

a first side;

a second side;

a proximity sensor configured to sense a distance to objects located to at least one of the first side and the second side of the vehicle;

a camera mounted at the front of the vehicle, the camera configured to include a field of view that includes a view to at least one of the first side and the second side of the vehicle;

a display in the vehicle; and

processing circuitry coupled to the proximity sensor, the camera, and the display, wherein the processing circuitry is configured to:

determine that, at least, the proximity sensor has detected a transition of the vehicle from surroundings of the vehicle in which at least one object located to at least one of the first side of the vehicle and the second side of the vehicle is within a predetermined proximity threshold distance to surroundings of the vehicle in which no objects are located to the at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance, and

in response to determining that, at least, the proximity sensor has detected the transition, the processing circuitry is configured to display video from the camera on the display of the vehicle, wherein

in determining that, at least, the proximity sensor has detected the transition, the processing circuitry is further configured to determine that prior to the transition the vehicle was traveling at a speed less than a predetermined speed threshold, and

the display of the video from the camera on the display is also conditioned on the vehicle having been trav-

eling at the speed less than the predetermined speed threshold prior to the transition.

2. The vehicle according to claim 1 wherein:

in determining that, at least, the proximity sensor has detected the transition, the processing circuitry is further configured to determine that prior to the transition, the vehicle had traveled a distance at least equal to a predetermined travel distance while the vehicle was in the surroundings of the vehicle in which at least one object was located to at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance.

3. The vehicle according to claim 1 wherein:

in determining that, at least, the proximity sensor has detected the transition, the processing circuitry is further configured to determine that prior to the transition, for at least a predetermine period of time the vehicle was in the surroundings of the vehicle in which at least one object was located to at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance.

4. The vehicle according to claim 1 wherein:

in determining that, at least, the proximity sensor has detected the transition, the processing circuitry is further configured to determine when a turn signal of the vehicle has been activated.

5. The vehicle according to claim 1 wherein:

the proximity sensor has a horizontal field of view at least partly overlaps the range of 75° to 85° degrees from a longitudinal axis of the vehicle.

6. The vehicle according to claim 1 wherein:

the field of view of the proximity sensor has a horizontal angular extent of at least 10 degrees.

7. A method of operating a camera and a display of a vehicle in response to a proximity sensor of the vehicle, the method comprising:

determining with processing circuitry that, at least, the proximity sensor has detected a transition of the vehicle from surroundings of the vehicle in which at least one object located to at least one of the first side of the vehicle and the second side of the vehicle is within a predetermined proximity threshold distance to surroundings of the vehicle in which no objects are located to the at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance; and

in response to determining that, at least, the proximity sensor has detected the transition, using the processing circuitry to display video from the camera on the display of the vehicle, wherein

determining that, at least, the proximity sensor has detected the transition, includes determining with the processing circuitry that prior to the transition the vehicle was traveling at a speed less than a predetermined speed threshold, and

the display of the video from the camera on the display is also conditioned on the vehicle having been traveling at the speed less than the predetermined speed threshold prior to the transition.

8. The method according to claim 7 wherein:

determining that, at least, the proximity sensor has detected the transition, includes determining that prior to the transition, the vehicle had traveled a distance at least equal to a predetermined travel distance while the vehicle was in the surroundings of the vehicle in which at least one object was located to at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance.

9. The method according to claim 7 wherein:

determining that, at least, the proximity sensor has detected the transition, includes determining that prior to the transition, for at least a predetermine period of time the vehicle was in the surroundings of the vehicle in which at least one object was located to at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance.

10. The method according to claim 7 wherein:

determining that, at least, the proximity sensor has detected the transition, includes determining when a turn signal of the vehicle has been activated.

11. A non-transitory computer readable medium including programming instructions for

operating a camera and a display of a vehicle in response to a proximity sensor of the vehicle, including programming instructions for:

determining with processing circuitry that, at least, the proximity sensor has detected a transition of the vehicle from surroundings of the vehicle in which at least one object located to at least one of the first side of the vehicle and the second side of the vehicle is within a predetermined proximity threshold distance to surroundings of the vehicle in which no objects are located to the at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance; and

in response to determining that, at least, the proximity sensor has detected the transition, using the processing circuitry to display video from the camera on the display of the vehicle, wherein

determining that, at least, the proximity sensor has detected the transition, includes determining with the processing circuitry that prior to the transition the vehicle was traveling at a speed less than a predetermined speed threshold, and

the display of the video from the camera on the display is also conditioned on the vehicle having been traveling at the speed less than the predetermined speed threshold prior to the transition.

12. The non-transitory computer readable medium according to claim 11 further including programming instructions for:

determining that, at least, the proximity sensor has detected the transition, includes determining that prior to the transition, the vehicle had traveled a distance at least equal to a predetermined travel distance while the vehicle was in the surroundings of the vehicle in which at least one object was located to at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance.

13. The non-transitory computer readable medium according to claim 11 further including programming instructions for:

determining that, at least, the proximity sensor has detected the transition, includes determining that prior to the transition, for at least a predetermine period of time the vehicle was in the surroundings of the vehicle in which at least one object was located to at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance.

US009964642B2

(12) **United States Patent**
Hada

(10) **Patent No.: US 9,964,642 B2**
(45) **Date of Patent: May 8, 2018**

(54) **VEHICLE WITH SYSTEM FOR DETECTING ARRIVAL AT CROSS ROAD AND AUTOMATICALLY DISPLAYING SIDE-FRONT CAMERA IMAGE**

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(72) Inventor: **Hideki Hada**, Ann Arbor, MI (US)

(73) Assignee: **TOYOTA MOTOR ENGINEERING & MANUFACTURING NORTH AMERICA, INC.**, Erlanger, KY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days. days.

(21) Appl. No.: **15/015,908**

(22) Filed: **Feb. 4, 2016**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

G01S 17/93	(2006.01)
G01S 13/93	(2006.01)
G01S 15/93	(2006.01)
G01S 17/02	(2006.01)
G01S 17/87	(2006.01)
G01S 15/02	(2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***G01S 13/931*** (2013.01); ***G01S 13/867*** (2013.01); ***G01S 13/87*** (2013.01); ***G01S 15/025*** (2013.01); ***G01S 15/87*** (2013.01); ***G01S 15/931*** (2013.01); ***G01S 17/023*** (2013.01); ***G01S 17/87*** (2013.01); ***G01S 17/936*** (2013.01); ***G08G 1/166*** (2013.01); *G01S 2013/9332* (2013.01); *G01S 2013/9364* (2013.01); *G01S 2013/9367* (2013.01); *G01S 2013/9375* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A vehicle includes a proximity sensor that senses a distance to objects located to at least one side of the vehicle, a camera mounted at the front of the vehicle, a display for displaying video from the camera, and processing circuitry that detects a transition of the vehicle from surroundings of the vehicle in which at least one object located to the side of the vehicle is within a predetermined proximity threshold distance to surrounding of the vehicle in which no objects are located to the side of the vehicle within the predetermined proximity threshold distance, and in response to determining that, at least, the proximity sensor has detected the transition, the processing circuitry is configured to display video from the camera on the display of the vehicle. Additional criteria for displaying the video can include vehicle speed, distance traveled prior to the transition, duration for which the state prior to the transition was maintained, and the state of the vehicle's turn signal.

14 Claims, 12 Drawing Sheets

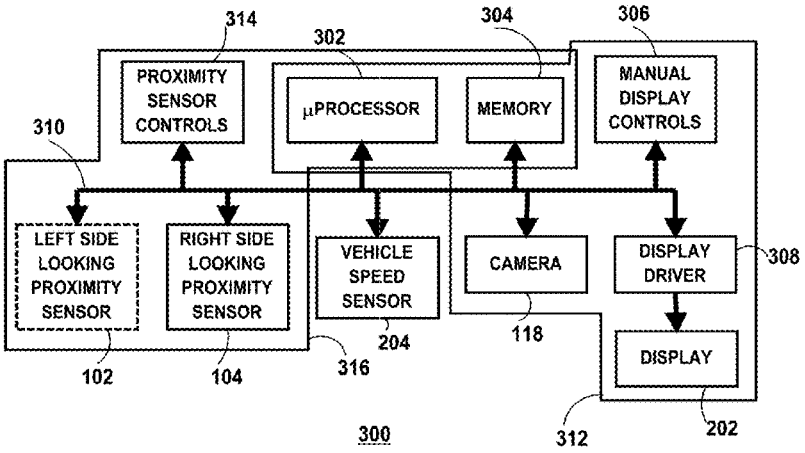


FIG. 15

FIFO BUFFER

LATERAL_DISTANCE(T_{-N})
LATERAL_DISTANCE(T_{-K})
LATERAL_DISTANCE(T_{-1})
LATERAL_DISTANCE(T_0)

1500

FIG. 16

FIFO BUFFER

Vehicle_Speed(T_{-N})
Vehicle_Speed(T_{-K})
Vehicle_Speed(T_{-1})
Vehicle_Speed(T_0)

1600

FIG. 17

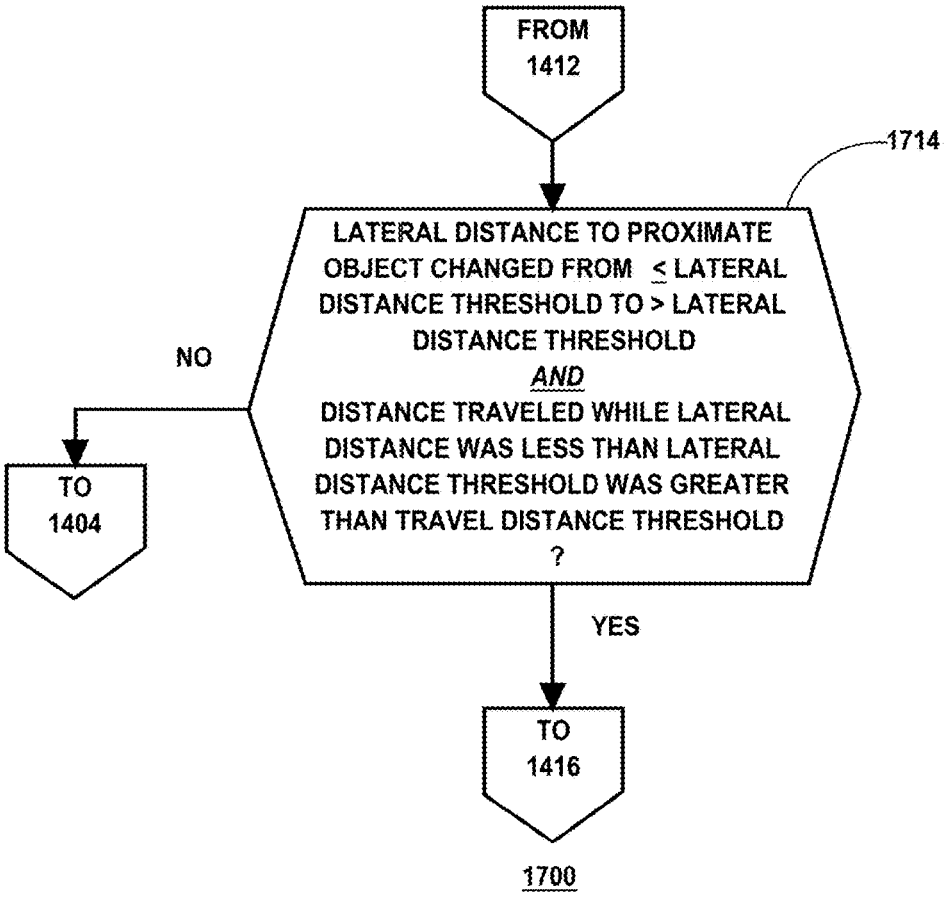


FIG. 19

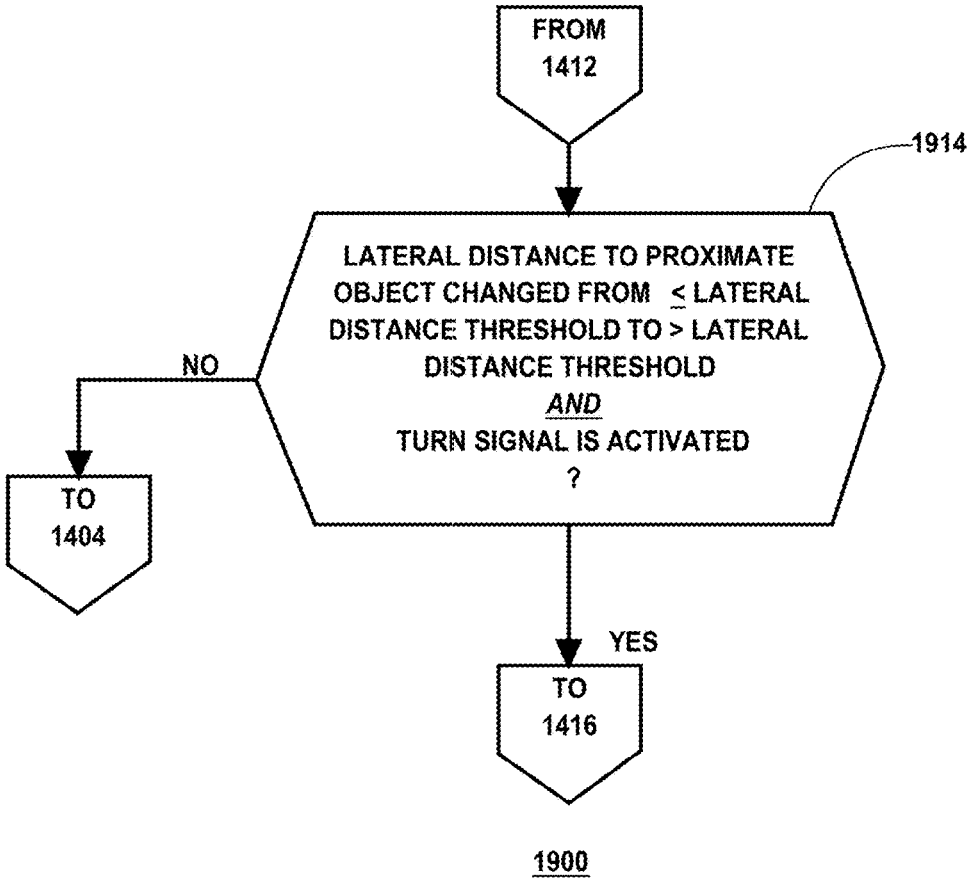
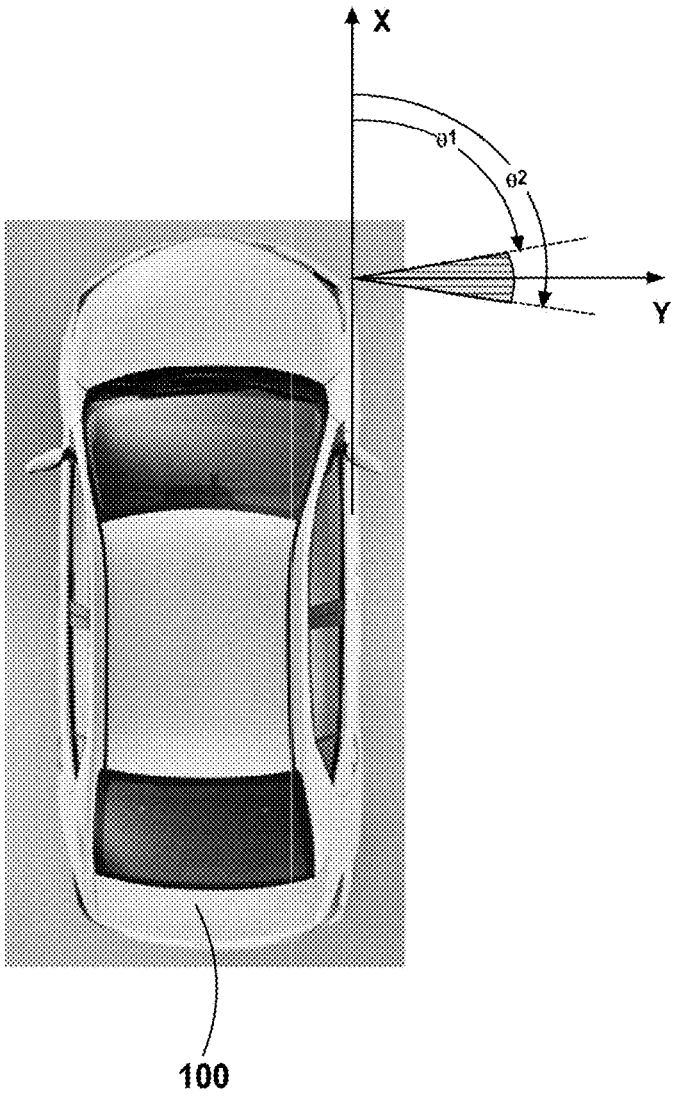

FROM 1412
1914
LATERAL DISTANCE TO PROXIMATE OBJECT CHANGED FROM ≤ LATERAL DISTANCE THRESHOLD TO > LATERAL DISTANCE THRESHOLD
AND
TURN SIGNAL IS ACTIVATED
?
NO
TO 1404
YES
TO 1416
1900

FIG. 20



VEHICLE WITH SYSTEM FOR DETECTING ARRIVAL AT CROSS ROAD AND AUTOMATICALLY DISPLAYING SIDE-FRONT CAMERA IMAGE

FIELD OF THE DISCLOSURE

This disclosure relates to vehicle safety systems.

BACKGROUND OF THE DISCLOSURE

A significant fraction of car accidents and a significant fraction of accident fatalities occur at intersections. Certain intersections are more dangerous due to the poor visibility with respect to cars approaching on cross roads from the perspective of a driver in a car stopped at the intersection. This may be due to the curvature of intersecting roads or due to the presence of objects such as parked cars, a building, a fence, a wall, trees or hedges near the intersection. The stopping point for cars at intersections is selected to keep stopped vehicles spaced at a safe distance from traffic on cross streets, but unfortunately may not afford a clear view of such traffic from the perspective of the driver's seat.

In the past there were efforts to address the problem by placing a wide angle camera at the front of a vehicle and routing the video feed from the camera to the vehicle's navigation display.

Additionally there have been efforts to automatically issue warnings to drivers. For example, U.S. Patent Publication 2015/0051753 to Kawamata et al. discloses providing a level of driving assistance in the form of warning lights or audio that is dependent on whether or not obstacles are detected at an intersection. Obstacles are detected using sound emitted by the vehicle and a set of microphones.

SUMMARY OF THE DISCLOSURE

Certain embodiments described herein include a vehicle including: a front; a first side; a second side; a proximity sensor configured to sense a distance to objects located to at least one of the first side and the second side of the vehicle; a camera mounted at the front of the vehicle, the camera configured to include a field of view that includes a view to at least one of the first side and the second side of the vehicle; a display in the vehicle; processing circuitry coupled to the proximity sensor, the camera, and the display, wherein the processing circuitry is configured to: determine that, at least, the proximity sensor has detected a transition of the vehicle from surroundings of the vehicle in which at least one object located to at least one of the first side of the vehicle and the second side of the vehicle is within a predetermined proximity threshold distance to surrounding of the vehicle in which no objects are located to the at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance; and in response to determining that, at least, the proximity sensor has detected the transition, the processing circuitry is configured to display video from the camera on the display of the vehicle.

In determining that, at least, the proximity sensor has detected the transition, the processing circuitry can be further configured to determine that prior to the transition the vehicle was traveling at a speed less than a predetermined speed threshold, and displaying the video from the camera on the display can also be conditioned on the vehicle having been traveling at the speed less than the predetermined speed threshold prior to the transition.

In determining that, at least, the proximity sensor has detected the transition, the processing circuitry can be further configured to determine that prior to the transition, the vehicle had traveled a distance at least equal to a predetermined travel distance while the vehicle was in the surroundings of the vehicle in which at least one object was located to at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance and displaying the video from the camera on the display can also be conditioned on the vehicle having traveled the distance equal to the predetermined travel distance while the vehicle was in surroundings of the vehicle in which at least one object was located to at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance.

In determining that, at least, the proximity sensor has detected the transition, the processing circuitry can be further configured to determine that prior to the transition, for at least a predetermine period of time the vehicle was in the surroundings of the vehicle in which at least one object was located to at least one of the first side of the vehicle and the second side of the vehicle within the predetermined proximity threshold distance.

In determining that, at least, the proximity sensor has detected the transition, the processing circuitry can be further configured to determine if a turn signal of the vehicle has been activated.

According to certain embodiments, the proximity sensor can have a horizontal field that has a horizontal angular extent of 10° to 20°.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a front view of a vehicle equipped with an automatic system for controlling a camera and a display at traffic intersections;

FIG. **2** is a top view of the vehicle shown in FIG. **1**.

FIG. **3** is a block diagram of the automatic system for controlling the camera and the display that are included in the vehicle shown in FIG. **1** and FIG. **2**;

FIG. **4** is flowchart of a first method of controlling the camera and the display of the vehicle shown in FIGS. **1-2** according to a first example provided in the present disclosure;

FIG. **5** is a flowchart of a second method of controlling the camera and the display of a vehicle shown in FIGS. **1-2** according to a second example provided in the present disclosure;

FIG. **6** is a first schematic representation of a driving environment illustrating a first scenario in which systems for controlling a camera and a display at intersections are used;

FIG. **7** is a graph including a plot of measured lateral distance to proximate objects versus vehicle position for the first scenario illustrated in FIG. **6**;

FIG. **8** is a second schematic representation of a driving environment illustrating a second scenario in which systems for controlling a camera and a display at intersections are used;

FIG. **9** is a graph including a plot of measured lateral distance to proximate objects versus vehicle position for the second scenario illustrated in FIG. **8**;

(whichever of the two is present), the proximity sensor controls **314**, the microprocessor **302** and the memory **304** make up a proximity sensor system **316**. The microprocessor **302** and the memory **304** can be included in the ECU **206**. The microprocessor **302** is one form of processing circuitry. Possible alternative forms of processing circuitry include, by way of nonlimitive example, an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), a microcontroller and/or discrete logic. Optionally the first vehicle **100** can include multiple separate microprocessors and/or microcontrollers that handle different control functions. The microprocessor **302**, the memory **304**, the camera **118**, the display driver **308**, the display **202** and the manual display controls **306** are parts of a camera system **312**. Note however that the microprocessor **302** and the memory **304** also perform functions outside of the camera system **312**.

FIG. **4** is a flowchart of a first method **400** of controlling the camera system **312** of the first vehicle **100** according to a first example provided in the present disclosure. The method **400** commences with decision block **402** which determines if the camera system **312** of the first vehicle **100** has been turned on. An occupant (e.g., a driver) of the first vehicle **100** can turn on the camera system **312** by operating the manual display controls **306**. If the outcome of decision block **402** is negative, then the method **400** branches to block **404** which signifies a state of the system **300** in which the camera system **312** is not used. Within the state in which the camera is not used **404**, the system **300** continues to check the outcome of block **402** to determine if the camera system **312** is turned on. When the outcome of decision block **402** is positive, the method **400** continues to decision block **406** the outcome of which depends on whether the proximity sensor system **316** is turned on. If the outcome of decision block **406** is negative, then the method **400** branches to block **408** which indicates a state of the system **300** in which the camera system **312** is used in manual mode. Within the state **408** in which the camera system **312** is used in manual mode, the system **300** continues to test the outcome of decision blocks **402** and **406** in order to handle user operation of the manual display controls **306** and the proximity sensor controls **314**. If, on the other hand, the outcome of decision block **406** is positive, then in block **410** the proximity sensor system **316** is used to measure the lateral distance to proximate objects. The proximate objects can, for example, be cars parked in a parking lane of a street on which the first vehicle **100** is driving, building walls, gates or booths in a parking garage or other structures on the side of a street or driveway.

Next decision block **412** tests if the lateral distance to proximate objects is less than a programmed lateral distance threshold. A positive outcome of decision block **412** is construed to signify that the first vehicle **100** is traveling along a road and has not yet reached an intersection. The programmed threshold can be made dependent on other factors, such as for example a location estimate for the vehicle or the average speed of the vehicle. The location estimate can be obtained from location services such as provided by cellular networks, Wi-Fi networks or satellite navigation services (e.g., GPS, GLONASS, BeiDou, Galileo). The lateral distance threshold can be set in accordance with stored information for a road that the vehicle **100** is traveling on as determined by the location services. When the outcome of decision block **412** is negative the method **400** branches to block **408** signifying the aforementioned state in which the camera system **312** is used in manual mode. While in manual mode the driver can use the manual display controls **306** to control the display **202**. When the outcome decision block **412** is positive, the method **400** proceeds to decision block **414** the outcome of which depends on whether the lateral distance to proximate objects changed from less than the programmed lateral distance threshold to greater than the programmed lateral distance threshold. Note that it can also be deduced that the lateral distance to proximate objects is beyond the programmed lateral distance if the programmed lateral distance is less than a maximum sensing range of the proximity sensor system **316** and nothing is detected by the proximity sensor system **316**. If the outcome of decision block **414** is negative the system **300** returns to the state in which the camera system **312** is used in manual mode **408** and continues executing blocks **402** et seq. When the outcome of decision block **414** is positive the method **400** proceeds to block **416** in which the camera system **312** displays video being acquired by the camera **118** on the display **202**. A positive outcome of decision block **414** is construed to mean that the first vehicle **100** has reached an intersection where a region to the side of the front of the first vehicle **100** which is being probed by the proximity sensor system **316** does not include objects within the programmed lateral distance threshold.

FIG. **5** is a flowchart of a second method **500** of controlling a camera system e.g., **312** of a vehicle e.g., **100** according to a second example. In block **502** the lateral distance to proximate objects is measured. Next decision block **504** tests if the lateral distance to proximate objects is less than a predetermined lateral distance threshold. If the outcome of decision block **504** is negative then the method **500** loops back to block **502** and continues executing as just described. When the outcome of decision block **504** is positive, the method proceeds to block **506** which again measures the lateral distance to proximate objects. Next decision block **508** tests if the lateral distance to proximate objects changed from less than the predetermined lateral distance threshold to greater than the predetermined lateral distance threshold. If the outcome of decision block **508** is negative then the method **500** loops back to block **506** and continues executing as described above. When the outcome of decision block **508** is positive indicating that the vehicle, e.g., **100** in which the method **500** is being executed has reached a traffic intersection, the method **500** proceeds to block **510** in which a video feed from a camera, e.g., **118** of the vehicle, e.g., **100** is displayed on a display, e.g., **202** of the vehicle, e.g., **100**. Next decision block **512** tests if the lateral distance to proximate objects is again less than the predetermined lateral distance threshold. If the outcome of decision block **512** is negative then the method loops back to block **512** and continues displaying the video feed on the camera. When the outcome of decision block **512** is affirmative, the method **500** proceeds to block **514** in which the displaying of the video feed from the camera is stopped. Next the method **500** loops back to block **506** and continues executing as previously described. According to certain alternative embodiments the lateral distance threshold used in blocks **504** and **512** are different.

FIG. **6** is a first schematic representation of a driving environment illustrating a first scenario **600** in which the system **300** for controlling the camera **118** and the display **202** at intersections is used. The first vehicle **100** is driving on a one-way street **606** between a first building **608** and a second building **610**. In the bottom and middle positions of the first vehicle **100** (drawn with a dashed outline) the proximity sensor system **316** detects the buildings **608**, **610** spaced laterally from the vehicle but within the aforementioned lateral distance threshold. When the first vehicle **100**

has reached an intersection **612** with a cross street **614**, the system **300** will detect opening up of the region to the sides of the front **116** of the first vehicle **100** and the video feed from the camera **118** will be displayed on the display **202**. The driver (not shown) of the first vehicle **100** will be able to see additional vehicles **616** which are driving on the cross street **614** on the display **202** without having to advance the first vehicle **100** dangerously into the cross street **614**

FIG. **7** is a graph **700** including a plot **702** of measured lateral distance to proximate objects versus position of the first vehicle **100** for the first scenario illustrated in FIG. **6**. In FIGS. **7**, **9**, **11** and **13**, an X-axis (abscissa) of each graph **700**, **900**, **1100**, **1300** indicates a position of the first vehicle **100** and a D-axis (ordinate) of each graph **700**, **900**, **1100**, **1300** indicates the lateral distance to proximate objects measured by the proximity sensor system **316**. As shown in FIG. **7** the lateral distance to proximate objects increases as the first vehicle **100** passes beyond the buildings **608**, **610** at the intersection **612**.

FIG. **8** is a second schematic representation of a driving environment illustrating a second scenario **800** in which the system **300** for controlling the camera **118** and the display **202** at intersections is used. In the second scenario **800** the first vehicle **100** is driving out of a parking garage **802** onto a cross street **804**. A gate or pair of booths **806** are located proximate an exit **808** of the parking garage **802**. The vehicle **100** must pass the gate or pair of booths **806**. FIG. **9** is a graph **900** including a plot **902** of measured lateral distance to proximate objects versus position of the vehicle **100** for the second scenario illustrated in FIG. **8**. While the front **116** of the first vehicle **100** is beside the gate or pair of booths **806**, the proximity sensor system **316** detects the gate or pair of booths as reflected in the plot **902**. Once the front **116** of the first vehicle **100** passes the gate or pair of booths **806** the proximity sensor system **316** will detect an opening up of the area around the front **116** of the first vehicle **100** and the system **300** will display video from the camera **118** on the display **202**.

FIG. **10** is a third schematic representation of a driving environment illustrating a third scenario **1000** in which the system **300** for controlling the camera **118** and the display **202** at intersections is used. In the third scenario **1000** the first vehicle **100** is driving in a center driving lane **1002** of a road **1004** that has cars **1006** parked in left side parking lane **1008** and a right side parking lane **1010**. The left proximity sensor field of view **208** and the right proximity sensor field of view are sufficiently wide relative to the spacing between the parked cars **1006** that the proximity sensor system **316** does not detect the small gaps between the parked cars **1006**. However when the first vehicle **100** passes the parked cars **1006** and reaches the intersection **612** with the cross street **614** the proximity sensors system **316** detects an opening up of the region to the side of the front **116** of the first vehicle **100** and in response thereto the system **300** will route video from the camera **118** to the display **202** allowing the driver of the first vehicle **100** to see additional vehicles **616** on the cross street **614**. FIG. **11** is a graph **1100** including a plot **1102** of measured lateral distance to from the first vehicle **100** to proximate objects versus the position of the first vehicle **100** for the third scenario illustrated in FIG. **10**.

FIG. **12** is a fourth schematic representation of a driving environment illustrating a fourth scenario **1200** in which the system **300** for controlling the camera **118** and the display **202** at intersections is used. In the fourth scenario **1200** the first vehicle **100** is driving on a street **1202** between two buildings **1204** that have irregularly shaped facades **1206**. The irregularly shaped facades **1206** undulate in square wave like fashion. As the first vehicle **100** drives between the two buildings **1204** the proximity sensor system **316** registers distances to proximate objects to the side of the vehicle that alternate between being below the lateral distance threshold and above the lateral distance threshold. FIG. **13** is a graph **1300** including a plot **1302** of measured lateral distance to proximate objects versus vehicle position for the fourth scenario illustrated in FIG. **12**. The plot **1302** shows how the measured lateral distances alternates between being above and below the lateral distance threshold. The fourth scenario can confound the methods **400**, **500** described above with reference to FIGS. **4-5**, leading to frequent unneeded routing of video from the camera **118** to the display **202**. To address the fourth scenario **1200** and other scenarios that would similarly create false triggers additional criteria and methods including such additional criteria, as described herein below, are provided.

FIG. **14** is a flowchart of a third method **1400** of controlling the camera **118** and the display **202** of the first vehicle **100** according to a third example provided in the present disclosure. In block **1404** the lateral distance to objects to at least one side of the first vehicle **100** is measured. The lateral distance to objects on both sides of the vehicle **100** or only one side of the vehicle **100** may be measured, as discussed above. In block **1406** the speed of the vehicle **100** is measured using the vehicle speed sensor **204**. In block **1408** the lateral distance that was measured in block **1404** is stored in a first First-In-First-Out (FIFO) buffer **1500** (FIG. **15**). The first FIFO buffer **1500** (FIG. **15**) can be implemented in the memory **304** as a circular buffer. In block **1410** the vehicle speed that was measured in block **1406** is stored in a second FIFO buffer **1600** (FIG. **16**). Next decision block **1412** tests if at least two lateral distance measurements have been stored (and by implication if at least two vehicle speed measurements have been stored). When, initially, the outcome of decision block **1412** is negative, the method **1400** loops back to block **1404** in order to re-execute blocks **1404-1410**. Once blocks **1404-1410** have been executed twice a transition from the lateral distance being below the lateral distance threshold to being above the lateral distance threshold can be detected. When the outcome of decision block **1412** is positive, the method **1400** proceeds to decision block **1414** the outcome of which depends on whether the lateral distance to proximate objects changed from less than lateral distance threshold to more than the lateral distance AND (in this specification a capitalized AND is a Boolean AND) the traveling speed when the lateral distance measured below the lateral distance threshold was less than a programmed speed threshold. Alternatively the traveling speed when the lateral distance measured above the lateral distance threshold can be used in block **1414**. A positive outcome of decision block **1414** is construed to mean that the vehicle **100** has reached an intersection and the method **1400** proceeds to block **1416** in which the video from the camera **118** is displayed on the display **202**. Including the speed criteria in **1414** is useful in avoiding false signals as it avoids triggering display of the video from the camera **118** when the vehicle **100** drives past a proximate object at a speed that would tend to indicate that the vehicle **100** has not approached an intersection. When the outcome of decision block **1414** is negative the method **1400** loops back to block **1404** and continues executing as described above. When the outcome of decision block **1414** is positive, after block **1416** and while continuing to display the video from the camera **118**, the method **1400** proceeds to block **1418** which signifies repeating execution of blocks **1404-1410** which results

(51) **Int. Cl.**

G01S 13/86	(2006.01)
G01S 13/87	(2006.01)
G01S 15/87	(2006.01)
G08G 1/16	(2006.01)

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14. The non-transitory computer readable medium according to claim 11 further including programming instructions for:

determining that, at least, the proximity sensor has detected the transition, includes determining when a turn signal of the vehicle has been activated.

* * * * *

FIG. 2

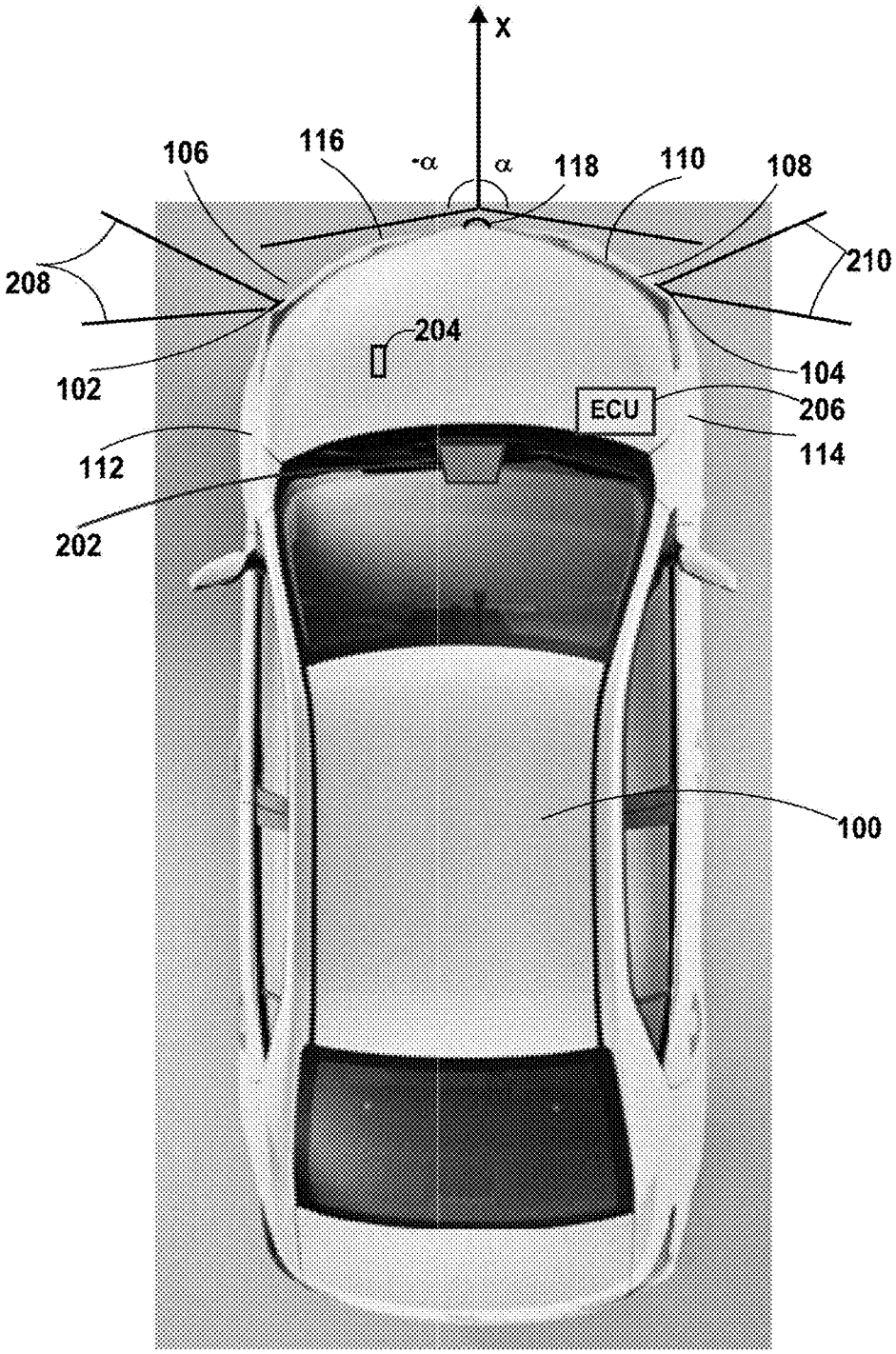
X
106
116
-α
α
118
110
108
208
210
204
102
104
ECU
206
112
114
202
100

FIG. 6

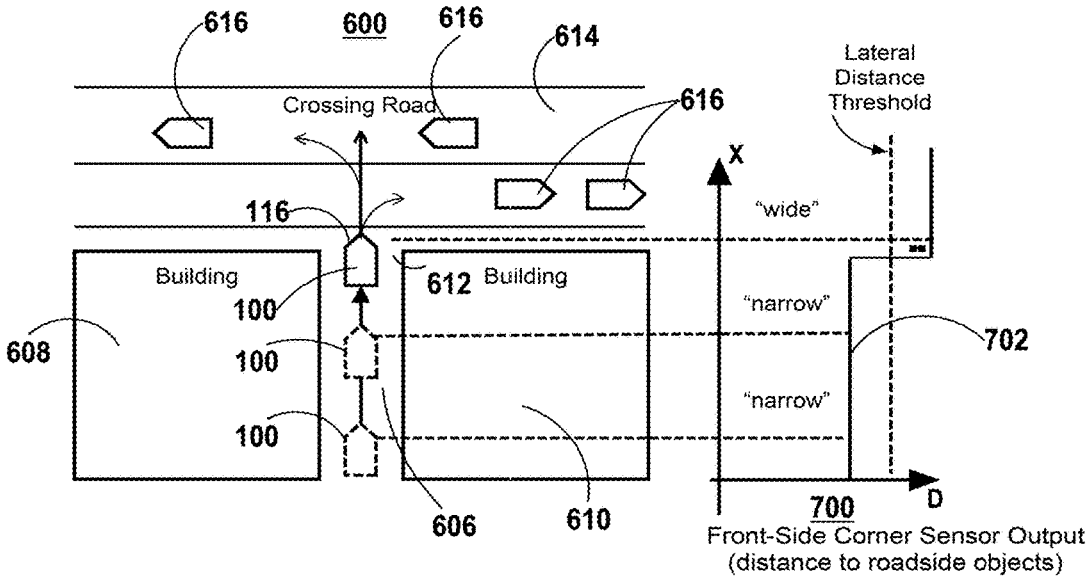

FIG. 7

FIG. 8

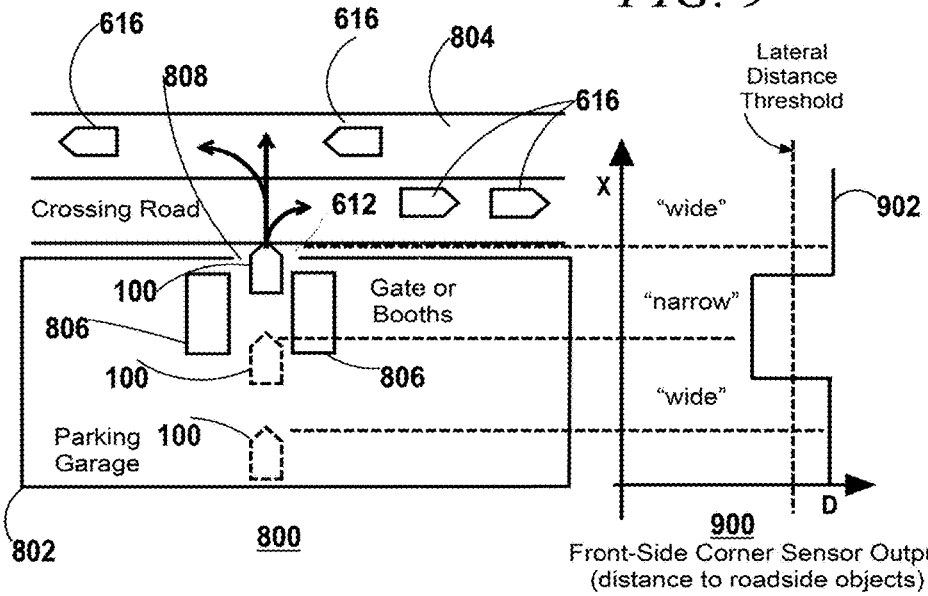

FIG. 9

FIG. 10

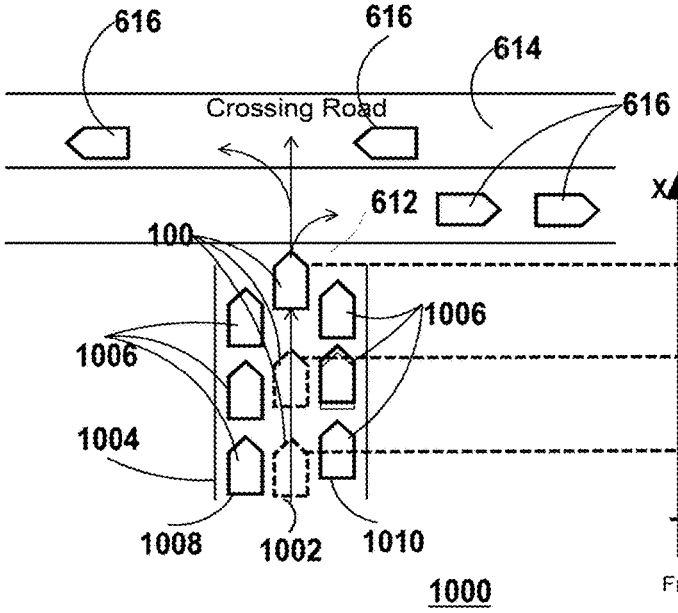

FIG. 11

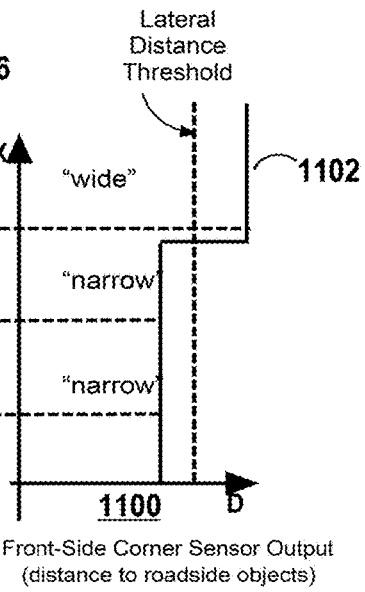

FIG. 12

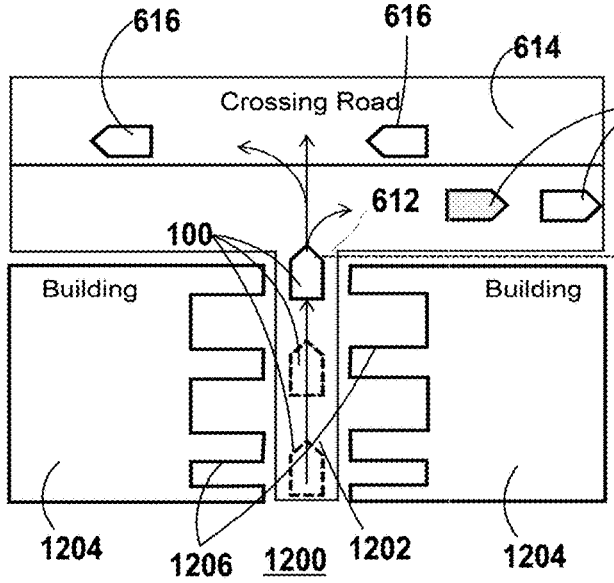
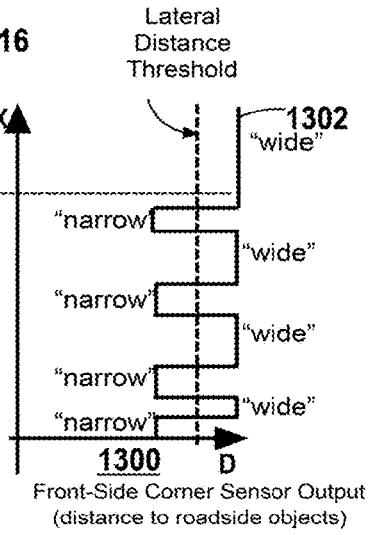
FIG. 13