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(54) Title: AUTOMATED VEHICLE OPERATION BASED ON OBSERVED MOVEMENT OF OTHER VEHICLES

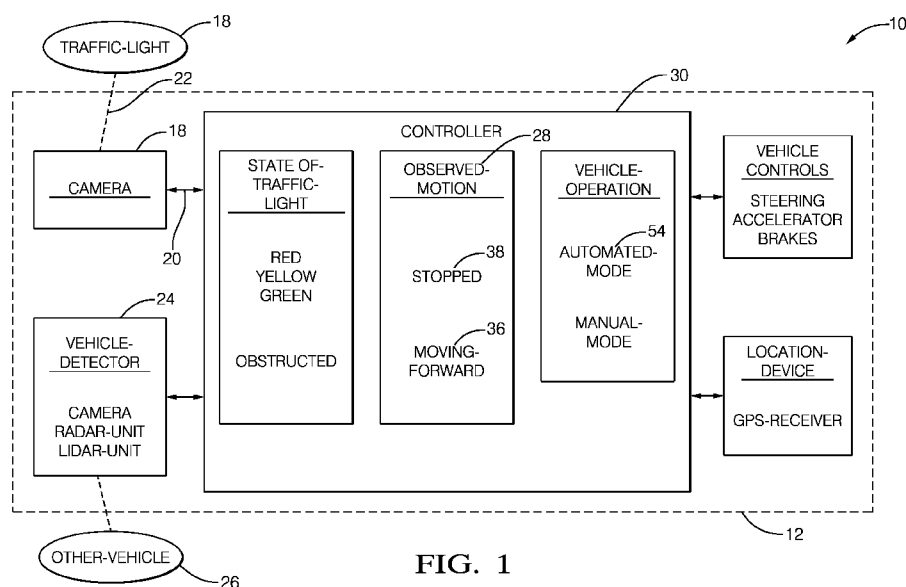


FIG. 1

(57) Abstract: A system (10) for operating an automated host-vehicle (12) includes a camera (14), an object-detector, and a controller (30). The camera (14) is suitable for use on a host-vehicle (12). The camera (14) is used to determine a state (16) of a traffic-light (18) based on an image (20) of the traffic-light (18) provided by the camera (14). The object-detector is suitable for use on the host-vehicle (12). The object-detector used to detect observed-motion (28) of an other-vehicle (26) proximate to the host-vehicle (12). The controller (30) is in communication with the camera (14) and the object-detector. The controller (30) is configured to operate the host-vehicle (12) in accordance with the observed-motion (28) of the other-vehicle (26) when the camera (14) is unable to view the traffic-light (18).

SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR,
TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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AUTOMATED VEHICLE OPERATION BASED ON OBSERVED MOVEMENT OF OTHER VEHICLES

TECHNICAL FIELD OF INVENTION

[0001] This disclosure generally relates to a system for operating an automated vehicle, and more particularly relates to operating a host-vehicle in accordance with an observed-motion of an other-vehicle when a camera of the system is unable to view a traffic-light.

BACKGROUND OF INVENTION

[0002] It is known to equip an autonomous or automated vehicle with a camera to detect the state (i.e. the color of light emitted by) a traffic-signal. However, in some circumstances the camera is unable to view a traffic-signal because the view is obstructed by, for example, a large truck.

SUMMARY OF THE INVENTION

[0003] In accordance with one embodiment, a system for operating an automated host-vehicle is provided. The system includes a camera, an object-detector, and a controller. The camera is suitable for use on a host-vehicle. The camera is used to determine a state of a traffic-light based on an image of the traffic-light provided by the camera. The object-detector is suitable for use on the host-vehicle. The object-detector used to detect observed-motion of an other-vehicle proximate to the host-vehicle. The controller is in communication with the camera and the object-detector. The controller is configured to

operate the host-vehicle in accordance with the observed-motion of the other-vehicle when the camera is unable to view the traffic-light.

[0004] Further features and advantages will appear more clearly on a reading of the following detailed description of the preferred embodiment, which is given by way of non-limiting example only and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0005] The present invention will now be described, by way of example with reference to the accompanying drawings, in which:

[0006] Fig. 1 is a diagram of an automate vehicle system, in accordance with one embodiment; and

[0007] Fig. 2 a traffic scenario encountered by the system of Fig. 1, in accordance with one embodiment.

DETAILED DESCRIPTION

[0008] Fig. 1 illustrates a non-limiting example of a system 10 for operating an automated host-vehicle, hereafter referred to as the host-vehicle 12. While the non-limiting examples presented herein are generally related to fully-automated vehicles, i.e. autonomous-vehicles, it is contemplated that the teachings presented herein are also applicable to vehicles that are less than fully-automated, i.e. partially-automated, where an operator (not shown) may manually control some aspect of the host-vehicle 12 such as the steering, but the operation of the accelerator and brakes is automated to maintain a predetermined distance behind another vehicle forward of the host-vehicle 12.

[0009] The system 10 includes a camera 14 suitable for use on a host-vehicle 12. The camera 14 is generally used by the system 10 to determine a state 16 of a traffic-light 18 based on an image 20 of the traffic-light 18 provided by the camera 14, but may be used for other purposes as well. That is, the camera 14 is not limited to only detection of the state 16 of the traffic-light 18. The camera 14 may be a 360 degree field-of-view type camera, or one of a plurality of cameras mounted at various locations on the host-vehicle 12. For use by the system 10 described herein, it is only necessary that the camera 14 is generally configured and positioned on the host-vehicle 12 so that the camera 14 is able to have a view or a line-of-site 22 to the traffic-light 18 in most traffic situations. It is recognized that in some traffic situations it may not be possible for the camera 14 to have the line-of-site 22 to the traffic-light 18 regardless of where on the host-vehicle 12 the camera 14 is located. As will be explained in more detail below, the system 10 is advantageously configured to overcome the problem of when the camera 14 is unable to view the traffic-light 18 because the line-of-site 22 is obstructed.

[0010] The system 10 also includes a vehicle-detector 24 suitable for use on the host-vehicle 12. By way of example and not limitation, the vehicle-detector 24 may include any one or combination of a camera, a radar-unit, a lidar-unit, an ultrasonic-transducer, or any other sensor technology useful to detect an other-vehicle 26 or objects proximate to the host-vehicle 12. The vehicle-detector 24 is generally used to detect movement or observed-motion 28 of the other-vehicle 26 relative to the host-vehicle 12 and/or any other objects or other vehicles proximate to the host-vehicle 12. The function of the vehicle-detector 24 may also be provided or supplemented by a transceiver (not shown) configured for vehicle-to-infrastructure (V2I) communications, vehicle-to-vehicle (V2V)

communications, and/or vehicle-to-pedestrian (V2P) communications, which may be generically labeled as V2X communications, as will be recognized by those in the art.

[0011] The system 10 also includes a controller 30 in communication with the camera 14 and the vehicle-detector 24. The controller 30 may include a processor (not specifically shown) such as a microprocessor or other control circuitry such as analog and/or digital control circuitry including an application specific integrated circuit (ASIC) for processing data as should be evident to those in the art. The controller 30 may include memory (not specifically shown), including non-volatile memory, such as electrically erasable programmable read-only memory (EEPROM) for storing one or more routines, thresholds, and captured data. The one or more routines may be executed by the processor to perform steps for determining the state 16 and the observed-motion 28 based on signals received by the controller 30 from the camera 14 and the vehicle-detector 24 as described herein. To overcome the problem of when the camera 14 is unable to view the traffic-light 18 because the line-of-site 22 is obstructed, the controller 30 is advantageously configured to operate the host-vehicle 12 in accordance with the observed-motion 28 of the other-vehicle 26 when the camera 14 is unable to view the traffic-light 18.

[0012] Fig. 2 illustrates a non-limiting example of a traffic-scenario 32 where the line-of-site 22 from the host-vehicle 12 to the traffic-light 18 of an intersection 40 is obstructed by a large-truck 34. If the traffic-light 18 changes from red to green, the system 10 or the controller 30 could wait until the large-truck 34 moves forward sufficiently so the line-of-site 22 is not obstructed and then operate the host-vehicle 12 in accordance the state 16 of the traffic-light. However, this would cause an undesirable

delay for the host-vehicle 12 to begin moving-forward. Preferably, the system 10 uses the vehicle-detector 24 to determine the observed-motion 28 of the other-vehicle 26, and act accordingly. That is, the host-vehicle 12 can proceed with moving-forward when the observed-motion 28 of the other-vehicle 26 is classified as moving-forward 36 rather than classified as being stopped 38.

[0013] Continuing to refer to Fig. 2, it is recognized that operating the host-vehicle 12 based on the action of a single instance of the other-vehicle 26 may not be considered sufficiently reliable. For example, if the other-vehicle 26 is being manually driven by a human operator, there are some unlikely circumstances when the other vehicle 26 could be moving-forward 36 even though the traffic-light 18 is red. For example, the human operator may have fallen asleep and inadvertently reduced pressure on the brake pedal while waiting for the traffic-light 18 to change from red to green. In order to avoid improper operation of the host-vehicle 12, the system 10 or the controller 30 may be configured to operate the vehicle to enter the intersection 40 when the other-vehicle includes a first-vehicle (e.g. the other-vehicle 26 shown in Fig. 2) in front of the host-vehicle 12 and a second-vehicle beside the host-vehicle 12 (e.g. the large-truck), and both the first-vehicle and the second-vehicle are moving into the intersection 40. That is, when the line-of-site 22 is obstructed, the system 10 may be configured so the host-vehicle 12 only proceeds toward and/or into the intersection when multiple instances of other-vehicles proximate to the host-vehicle 12 begin to move-forward to enter the intersection.

[0014] Accordingly, a system 10, a controller 30 for the system 10, and a method of operating the system 10 is provided. While it is expected that in most circumstances the line-of-site 22 will not be obstructed, the system 10 described herein provides a way to avoid unnecessary delays in the general flow of traffic caused by the host-vehicle 12 when the line-of-site 22 from the host-vehicle 12 to a relevant instance of the traffic-light is obstructed.

[0015] While this invention has been described in terms of the preferred embodiments thereof, it is not intended to be so limited, but rather only to the extent set forth in the claims that follow.

WE CLAIM:

1. A system (10) for operating an automated host-vehicle (12), said system (10) comprising:
a camera (14) suitable for use on a host-vehicle (12), said camera (14) used to determine a state (16) of a traffic-light (18) based on an image (20) of the traffic-light (18) provided by the camera (14);
an object-detector suitable for use on the host-vehicle (12), said object-detector used to detect observed-motion (28) of an other-vehicle (26) proximate to the host-vehicle (12); and
a controller (30) in communication with the camera (14) and the object-detector, said controller (30) configured to operate the host-vehicle (12) in accordance with the observed-motion (28) of the other-vehicle (26) when the camera (14) is unable to view the traffic-light (18).
2. The system (10) in accordance with claim 1, wherein the controller (30) operates the vehicle to enter an intersection (40) when the other-vehicle (26) includes a first-vehicle in front of the host-vehicle (12) and a second-vehicle beside the host-vehicle (12), and both the first-vehicle and the second-vehicle are moving into the intersection (40)

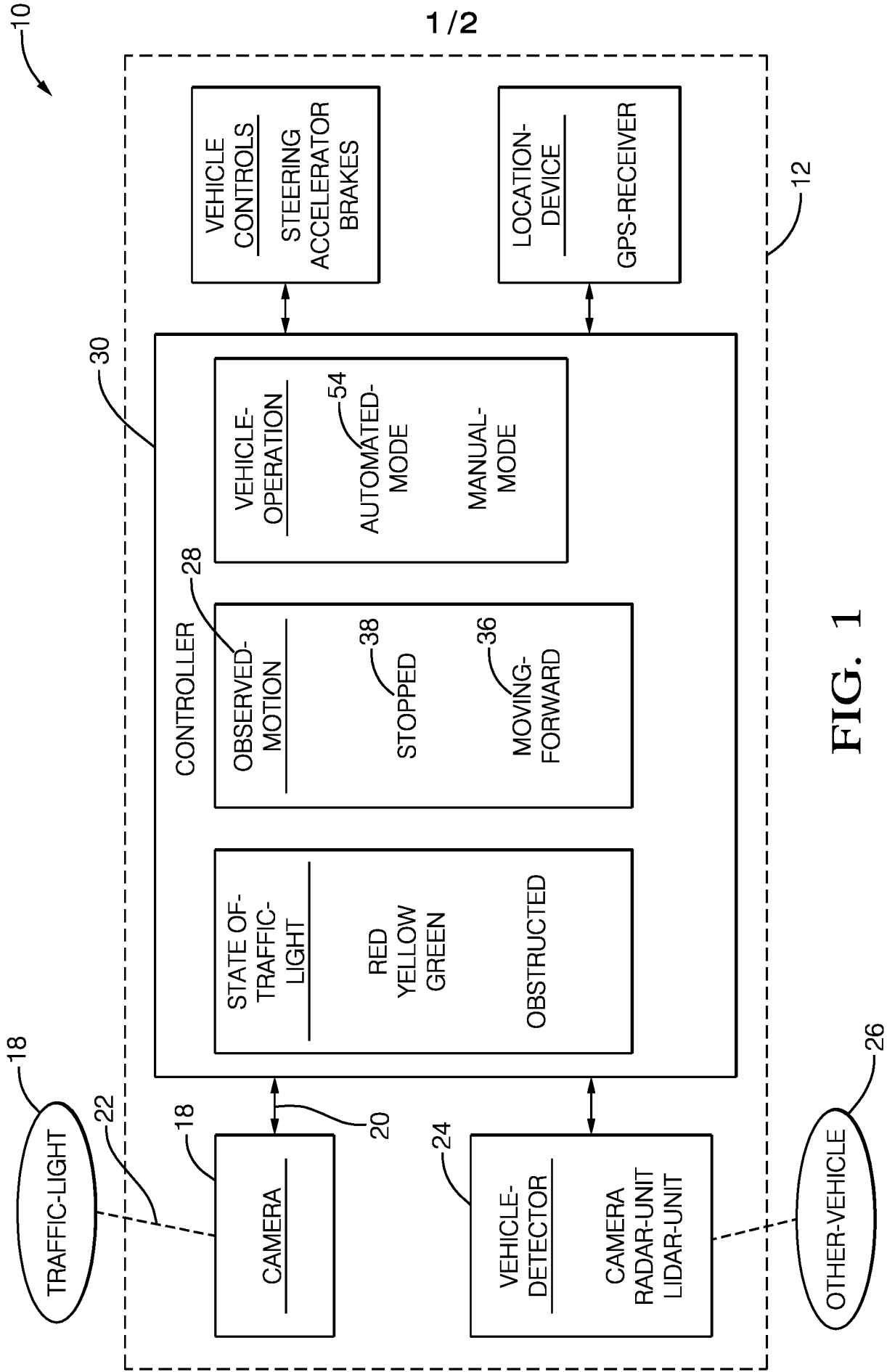


FIG. 1

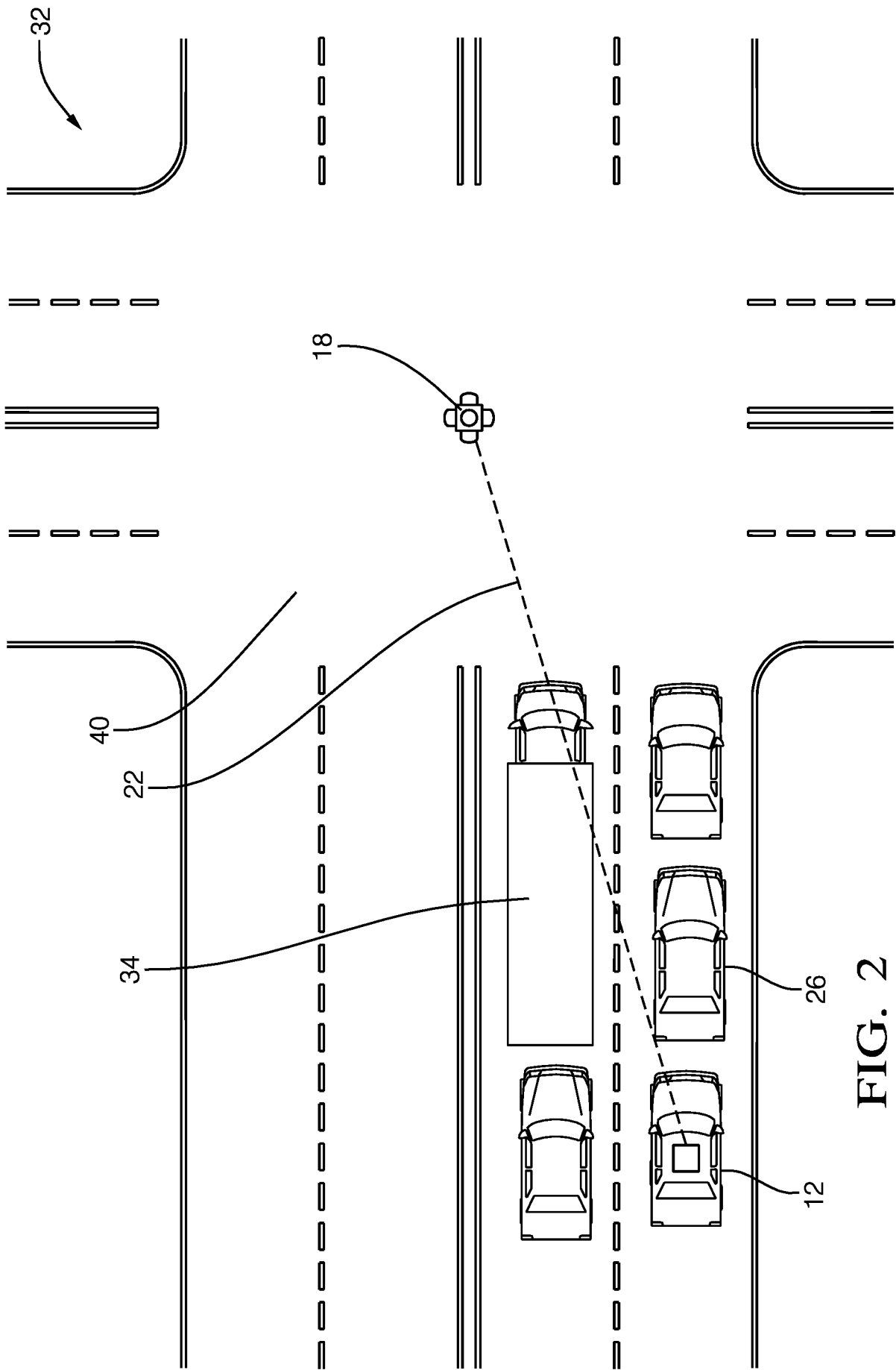


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/017120**A. CLASSIFICATION OF SUBJECT MATTER****G08G 1/16(2006.01)i, G08G 1/017(2006.01)i**

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)

G08G 1/16; B60R 1/00; B60T 8/32; B60W 50/08; B60W 30/00; G06K 9/00; B60W 40/02; G08G 1/09; G08G 1/017

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: automated vehicle, camera, traffic-light, object-detector, intersection

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009-0174573 A1 (ALEXANDER E. SMITH) 09 July 2009 See paragraphs [0059]-[0079]; claims 1-4 and figures 8-11.	1-2
Y	US 2014-0222280 A1 (MAGNA ELECTRONICS INC.) 07 August 2014 See paragraph [0012]-[0029]; claim 1 and figures 2-3.	1-2
A	US 2015-0329107 A1 (FORD GLOBAL TECHNOLOGIES, LLC) 19 November 2015 See paragraphs [0007]-[0019]; claims 1-20 and figures 1-3.	1-2
A	KR 10-2013-0085235 A (DONG YONG KIM) 29 July 2013 See paragraphs [0024], [0032]; claim 1 and figure 1.	1-2
A	US 2008-0071460 A1 (GUIXIAN LU) 20 March 2008 See paragraphs [0014]-[0031]; claim 1 and figure 1.	1-2



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

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Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

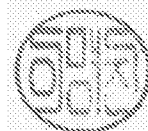


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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/017120

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