



(51) International Patent Classification:

B60W 30/14 (2006.01) B60W 60/00 (2020.01)

B60W 30/18 (2012.01)

(21) International Application Number:

PCT/EP2021/059474

(22) International Filing Date:

13 April 2021 (13.04.2021)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

10 2020 110 310.7

15 April 2020 (15.04.2020) DE

(71) Applicant: VALEO SCHALTER UND SENSOREN GMBH [DE/DE]; Laiernstr. 12, 74321 Bietigheim-Bissingen (DE).

(72) Inventor: WILHELM, Frederic; c/o Valeo Vision 34 rue Saint Andre, 93012 Bobigny (FR).

(74) Agent: CLAASSEN, Maarten; Laiernstr. 12, 74321 Bietigheim-Bissingen (DE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,

DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: DETECTION OF OBSTACLES IN A CURVED ROAD

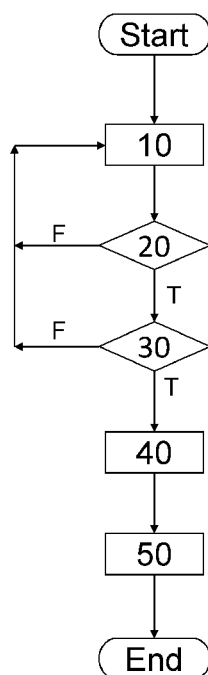


Fig. 5

(57) Abstract: The invention refers to a method for detecting obstacles in a curved road by front detecting means of a vehicle, in particular of an ego vehicle, wherein a front detection area of the front detecting means is in front of the vehicle, the method comprising the following steps: acquiring (10), by acquiring means, information about a vehicle environment; determining (20), by a computing system, based on the information about the vehicle environment, if the vehicle reaches a curve; if yes (T), determining (30), by the computing system, if a lane change to a lane of the road which is less inside the curve is possible; and if yes (T), manoeuvring (40), by a vehicle controlling system, the vehicle to the lane of the road which is less inside the curve.



Detection of obstacles in a curved road

The present invention refers to a method for detecting obstacles in a curved road by front detecting means of a vehicle, wherein a front detection area of the front detecting means is in front of a vehicle environment.

The present invention also refers to a system for detecting obstacles in a curved road by front detecting means of a vehicle, wherein a front detection area of the front detecting means is in front of a vehicle environment.

Furthermore, the present invention refers to a vehicle comprising the system.

Furthermore, the present invention refers to a computer program comprising instructions which, when the program is executed by a computer, cause the computer to execute the steps of the method.

Furthermore, the present invention refers to a data carrier signal, which the computer program transmits.

Furthermore, the present invention refers to a computer-readable medium comprising instructions which, when executed by a computer, cause the computer to execute the steps of the method.

According to prior art methods, in order to improve a viewing angle on different types of roads (e.g. a road that is more or less straight or one containing curves), information obtained from different types of sensor is combined. The latter process is also known as sensor fusion. Also, a combination of road map information or information obtained through communication with other vehicles is known to provide a suitable assessment of the traffic situation and possible dangers.

It is an object of the present invention to provide an improved method, an improved system, an improved vehicle, an improved computer program, an improved data carrier signal and an improved computer-readable medium. It is in particular an object of the

invention to detect more quickly obstacles that may be present beyond a curve in a road.

This object is achieved by the independent claims. Advantageous embodiments are given in the dependent claims.

In particular, the present invention provides a method for detecting obstacles in a curved road by front detecting means of a vehicle, in particular of an ego vehicle, wherein a front detection area of the front detecting means is in front of the vehicle, the method comprising the following steps: acquiring, by acquiring means, information about a vehicle environment; determining, by a computing system, based on the information about the vehicle environment, if the vehicle reaches a curve; if yes, determining, by the computing system, if a lane change to a lane of the road which is less inside the curve is possible; and if yes, manoeuvring, by a vehicle controlling system, the vehicle to the lane of the road which is less inside the curve (an more outwardly lying lane).

Preferably, the last step of the method is executed in the vehicle.

According to a first step, the method comprises acquiring, by acquiring means, information about a vehicle environment. The acquiring means may be integrated in the vehicle or may be located outside the vehicle. The information may have been retrieved or detected by the vehicle itself, or the vehicle may have received the information from another vehicle or an external server.

After the step of acquiring, the method comprises, according to a second step, determining, by a computing system, based on the information about the vehicle environment, if the vehicle reaches a curve. It may be a curve where the computing system has the information that the curve is to be driven or the system recognises that the curve is to be driven, e.g. on the basis of driver behaviour or statistics on usual routes of the vehicle. The curve can also be on the only route the vehicle can take.

In the affirmative/if yes, that means, if the computing system determines based on the information about the vehicle environment, that the vehicle reaches a curve, the method comprises determining, by the computing system, if a lane change to a lane of the road

which is less inside the curve (or is a more external one) is possible. This step can be based on information already retrieved in the first step.

In the affirmative/if yes, that means, if the computing system determines that a lane change to a lane of the road which is less inside the curve is possible, the method comprises manoeuvring, by a vehicle controlling system, the vehicle to the lane of the road which is less inside the curve.

In other words, two conditions are successively checked, both of which must be fulfilled for a lane change to take place.

The present invention also provides a system for detecting obstacles in a curved road by front detecting means of a vehicle, in particular of an ego vehicle, wherein a front detection area of the front detecting means is in front of the vehicle, the system comprising: acquiring means configured to acquire information about a vehicle environment; a computing system configured to determine, based on the information about the vehicle environment, if the vehicle reaches a curve, if yes, to determine, if a lane change to a lane of the road which is less inside the curve is possible; and a vehicle controlling system configured to, if yes, manoeuvre the vehicle to the lane of the road which is less inside the curve.

Additionally, the system may comprise means according to method steps according to any of the modified embodiments described below.

The present invention also provides a vehicle comprising the system. Preferably, the vehicle is an ego vehicle of a driver.

The present invention also provides a computer program comprising instructions which, when the program is executed by a computer, cause the computer to execute the steps of the method. A computer program is a collection of instructions for performing a specific task that is designed to solve a specific class of problems. The instructions of a program are designed to be executed by a computer and it is required that a computer can execute programs in order for it to function.

The present invention also provides a data carrier signal, which the computer program transmits.

The present invention also provides a computer-readable medium comprising instructions which, when executed by a computer, cause the computer to execute the steps of the method.

The basic idea of the invention is to have an automated system in the vehicle, when the vehicle is approaching a curve, carry out a lane change to a more outer lane, if it is available, where the visibility is better (objects potentially lying beyond the curve can be detected earlier) and the lateral acceleration is reduced, e. g. due to smaller curvature.

The invention allows avoiding for the vehicle to decrease its velocity in the curve and ensuring a better visibility and anticipation of events that lie ahead.

According to a modified embodiment of the invention, before and/or during a passage of the curve the front detecting means with the front detection area captures the vehicle environment. In other words, when driving through the outer lane of the curve, the front detecting means can permanently detect the environment of the vehicle. One benefits from an increased angle of view into the curve due to the location of the vehicle in the outer lane.

According to a modified embodiment of the invention, before and/or during a passage of the curve a vehicle speed is maintained or reduced in accordance with a curvature of the lane in which the vehicle is located. Depending on the driving situation, maximum driving comfort can be maintained with advantage.

According to a modified embodiment of the invention, the step of acquiring, by the acquiring means, information about the vehicle environment comprises a step of detecting, by a detecting system comprising the front detecting means, the vehicle environment. It is therefore advantageous to obtain very up-to-date information about the vehicle's environment.

According to a modified embodiment of the invention, the acquiring means comprises a sensing system; and/or a map of the road; and/or communicating means. Thus,

depending on the driving situation, a combination of the aforementioned information sources/detection means can be chosen with advantage. This can be done, for example, depending on how up-to-date the available information is and/or the reliability of the information source. The sensing system may comprise one or more sensors installed on the vehicle. This may include a camera, LIDAR, laser sensors, ultrasonic sensors, etc.

According to a modified embodiment of the invention, the front detecting means comprises at least partially the sensing system. In other words, sensors located in the front area of the vehicle can form the front detecting means.

According to a modified embodiment of the invention, the step of determining, by the computing system, if the lane change to a lane of the road which is less inside the curve is possible, comprises an evaluation of at least one of the following criteria:

- is there another lane in a same direction of travel as the lane currently in use;
- is there or not an impediment to the lane change;
- can the lane change be carried out without affecting a traffic flow in the other lane in the same direction of travel;
- does the other lane in the same direction of travel not separate to another destination;
- is there or not any "keep right/left unless overtaking" rule in the road regulation applicable to the current geographical area;

wherein a respective queried criterion must be fulfilled.

The information can be partially checked externally by the vehicle or internally. A safer lane change is thus provided with advantage.

According to a modified embodiment of the invention, the method comprises, after having passed the curve, changing to a lane, in which the vehicle was located before passing the curve. This can be decided by the computing system depending on typical driving behaviour, a traffic situation or other information received. Depending on the situation, a faster traffic flow can also be promoted.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter. Individual features disclosed in the

embodiments can constitute alone or in combination an aspect of the present invention. Features of the different embodiments can be carried over from one embodiment to another embodiment.

In the drawings:

- Fig. 1 schematically shows a first scene of a scenario, in which an embodiment of the method is applied;
- Fig. 2 schematically shows a second scene of the scenario, in which the embodiment of the method is applied;
- Fig. 3 schematically shows a third scene of the scenario, in which the embodiment of the method is applied;
- Fig. 4 schematically shows a fourth scene of the scenario, in which the embodiment of the method is applied; and
- Fig. 5 shows a flow chart of the method according to an embodiment of the invention.

Figure 1 schematically shows a first scene of a scenario, in which an embodiment of the method is applied.

In the scene, there is shown a road on which a vehicle 2 drives. The road 1 comprises two lanes 1a, 1b. The road 1 also comprises a curve. The vehicle 2 has front detecting means (not shown), which are configured to survey a front detection area 3 of the vehicle 2, which is in an environment of the vehicle 2 in front of the vehicle 2. The front detecting means of the vehicle 2 cannot detect obstacles, such as an obstacle 4, in the curve of the road 1 or behind the curve of the road 1 in the present scene due to a visibility barrier 5. The objective of this invention is to add a logic in the maneuver planner to change lane depending on visibility of the different lanes in highly curved roads 1. The vehicle 2, which is an ego vehicle, arrives on the curve in the interior or middle lane.

Fig. 5 shows a flow chart of the method according to an embodiment of the invention. The method is suitable for detecting obstacles in the curved road 1 by the front detecting means of the vehicle 2. The method comprises the following steps:

According to a step indicated by reference sign “10”, the method comprises acquiring, by acquiring means, information about a vehicle environment. The step of acquiring, by the acquiring means, information about the vehicle environment comprises a step of detecting, by a detecting system comprising the front detecting means, the vehicle environment. The acquiring means comprises a sensing system, a map of the road and communicating means. The front detecting means comprises at least partially the sensing system. The front detecting means is a camera, or a laser scanner or it comprises ultrasonic sensors, for example.

According to a step indicated by reference sign “20”, the method comprises determining, by a computing system (not shown), based on the information about the vehicle environment, if the vehicle 1 reaches the curve. In the present case, the vehicle 2 is intended to pass through this curve.

According to a step indicated by reference sign “30”, the method comprises, if yes (or shortly indicated by “true” or “T” in Fig. 5), determining, by the computing system, if a lane change to a lane 1a, 1b of the road 1 which is less inside the curve is possible. The step “30” of determining, by the computing system, if the lane change to a lane 1a, 1b of the road, which is less inside the curve is possible, comprises querying all of the following criteria:

- is there another lane 1a, 1b in a same direction of travel as the lane 1a, 1b currently in use;
- isn't there an impediment to the lane change;
- can the lane change be carried out without affecting a traffic flow in the other lane 1a, 1b in the same direction of travel;
- does the other lane 1a, 1b in the same direction of travel not separate to another destination?
- whether or not there is a “keep right/left unless overtaking” rule in the road regulation that is applicable to the area in which the vehicle 2 is currently moving;

A respective queried criterion must be fulfilled (T).

According to a succeeding step indicated by reference sign "40", the method comprises, if yes (or shortly indicated by "true" or "T" in Fig. 5), that means, if the further determination also provides a positive (true) result, manoeuvring, by a vehicle controlling system, the vehicle 2 to the lane 1b of the road 1 which is less inside the curve (see also Figures 2 and 3).

Then the front detecting means of vehicle 2 can detect an obstacle 4 (see Figures 3 and 4) and take evasive action if necessary.

According to a step indicated by reference sign "50", the method comprises, after having passed the curve, changing to the lane 1a, in which the vehicle 2 was located before passing the curve (see Fig. 4).

Before and during a passage of the curve the front detecting means with the front detection area 3 captures the vehicle environment. Furthermore, if possible, before and during a passage of the curve a vehicle speed is maintained or reduced in accordance with a curvature of the lane 1a, 1b in which the vehicle 2 is located.

On the drawings, the road 1 is turning right, so the interior lane is the right lane and the exterior lane is the left lane. The principle is of course applicable in the reverse situation (left turn).

Reference signs

- 1 road
- 1a, 1b lane
- 2 vehicle
- 3 front detection area
- 4 obstacle
- 5 visibility barrier

- 10 acquiring, by acquiring means, information about a vehicle environment
- 20 determining, by a computing system, based on the information about the vehicle environment, if the vehicle reaches a curve
- 30 if yes, determining, by the computing system, if a lane change to a lane of the road which is less inside the curve is possible
- 40 if yes, manoeuvring, by a vehicle controlling system, the vehicle to the lane of the road which is less inside the curve
- 50 changing to a lane, in which the vehicle was located before passing the curve

Claims

1. Method for detecting obstacles in a curved road (1) by front detecting means of a vehicle (2), in particular of an ego vehicle, wherein a front detection area (3) of the front detecting means is in front of the vehicle (2), the method comprising the following steps:
 - acquiring (10), by acquiring means, information about a vehicle environment;
 - determining (20), by a computing system, based on the information about the vehicle environment, if the vehicle (1) reaches a curve;
 - if yes (T), determining (30), by the computing system, if a lane change to a lane (1a, 1b) of the road (1) which is less inside the curve is possible; and
 - if yes (T), manoeuvring (40), by a vehicle controlling system, the vehicle (2) to the lane (1b) of the road (1) which is less inside the curve.
2. Method according to claim 1, wherein before and/or during a passage of the curve the front detecting means with the front detection area (3) captures the vehicle environment.
3. Method according to claim 1 or 2, wherein before and/or during a passage of the curve a vehicle speed is maintained or reduced in accordance with a curvature of the lane (1a, 1b) in which the vehicle (2) is located.
4. Method according to any of the preceding claims, wherein the step of acquiring (10), by the acquiring means, information about the vehicle environment comprises a step of detecting, by a detecting system comprising the front detecting means, the vehicle environment.
5. Method according to any of the preceding claims, wherein the acquiring means comprises a sensing system; and/or a map of the road; and/or communicating means.

6. Method according to the preceding claim, wherein the front detecting means comprises at least partially the sensing system.
7. Method according to any of the preceding claims, wherein the step of determining (30), by the computing system, if the lane change to a lane (1a, 1b) of the road which is less inside the curve is possible, comprises querying of at least one of the following criteria:
 - is there another lane (1a, 1b) in a same direction of travel as the lane (1a, 1b) currently in use;
 - isn't there an impediment to the lane change;
 - can the lane change be carried out without affecting a traffic flow in the other lane (1a, 1b) in the same direction of travel;
 - does the other lane (1a, 1b) in the same direction of travel not separate to another destination;wherein a respective queried criterion must be fulfilled (T).
8. Method according to any of the preceding claims, comprising, after having passed the curve, changing (50) to a lane (1a, 1b), in which the vehicle (2) was located before passing the curve.
9. Computer program comprising instructions which, when executed by a computer, cause the computer program to perform the method according to any of the preceding claims.
10. Data carrier signal transmitted by the computer program according to the claim 9.
11. Computer-readable medium, comprising instructions which, when executed by a computer, cause the computer to perform the method according to any of the claims 1 to 8.
12. System for detecting obstacles in a curved road (1) by front detecting means of a vehicle (2), in particular of an ego vehicle, wherein a front detection area (3) of the front detecting means is in front of the vehicle (2), the system comprising:

- acquiring means configured to acquire information about a vehicle environment;
- a computing system configured to
 - o determine, based on the information about the vehicle environment, if the vehicle (1) reaches a curve,
 - o if yes (T), to determine, if a lane change to a lane (1a, 1b) of the road (1) which is less inside the curve is possible; and
- a vehicle controlling system configured to
 - o if yes (T), manoeuvre the vehicle (2) to the lane (1b) of the road (1) which is less inside the curve; or

the system comprising means according to method steps according to any of the preceding dependent method claims.

13. Vehicle with a system according to the preceding claim.

1/2

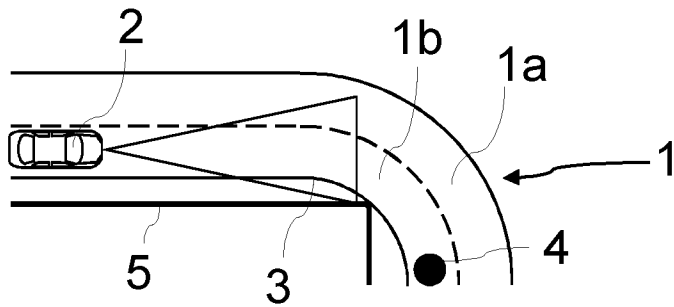


Fig. 1

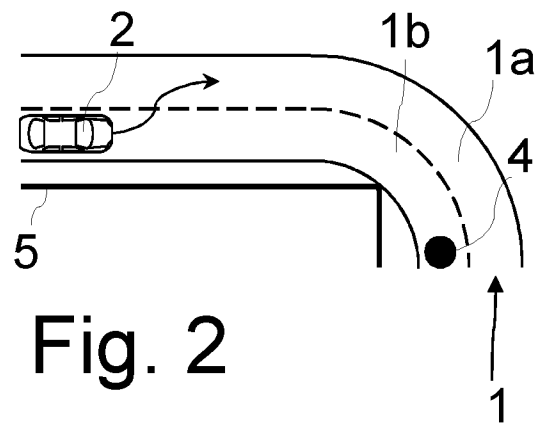


Fig. 2

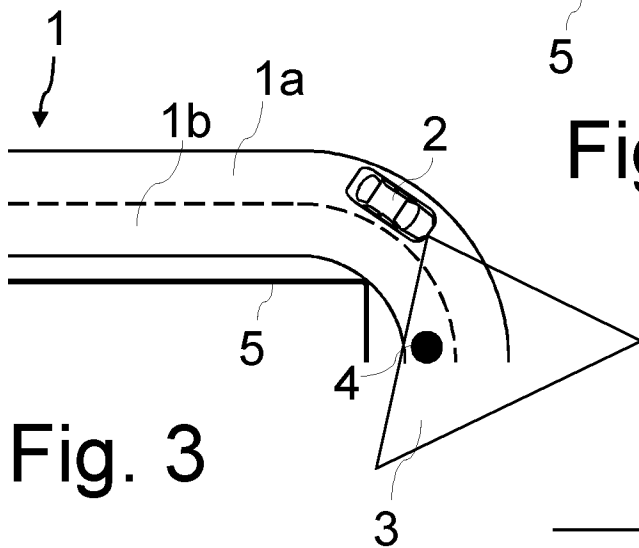


Fig. 3

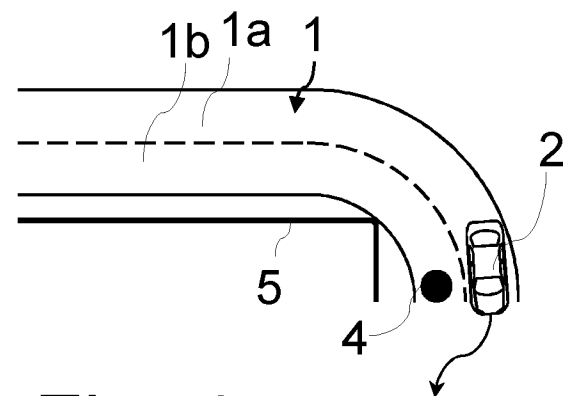


Fig. 4

2/2

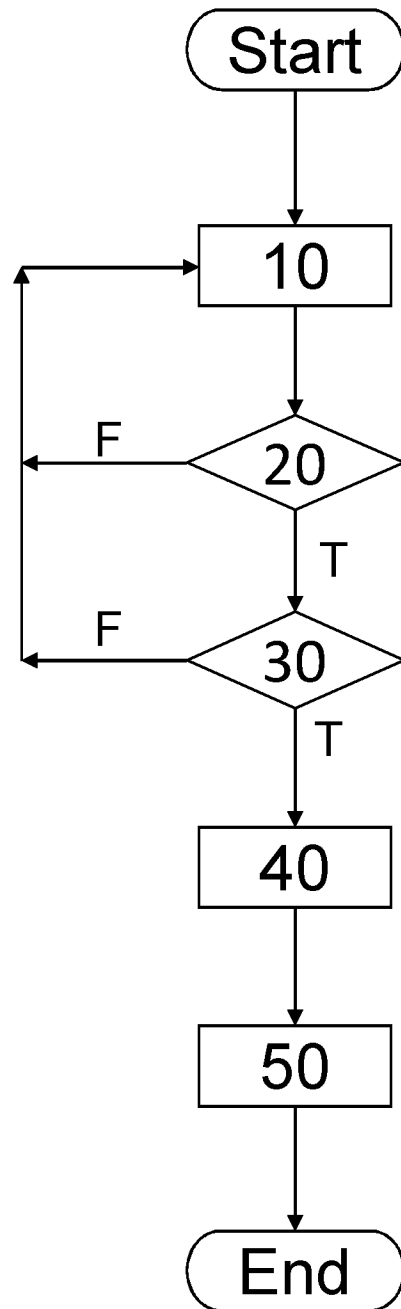


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/059474

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60W30/14 B60W30/18 B60W60/00
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)
B60W

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 10 2016 216335 A1 (CONTINENTAL AUTOMOTIVE GMBH) 1 March 2018 (2018-03-01) paragraphs [0002], [0015], [0040] -----	1-13
Y	DE 10 2018 111070 A1 (AUDI AG) 14 November 2019 (2019-11-14) paragraphs [0032], [0045], [0050] -----	1-13
Y	DE 10 2019 110925 A1 (GM GLOBAL TECH OPERATIONS LLC [US]) 14 November 2019 (2019-11-14) paragraph [0036] -----	3



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

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

25 June 2021

Date of mailing of the international search report

05/07/2021

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Stolle, Martin

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2021/059474

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102016216335 A1	01-03-2018	DE 102016216335 A1	01-03-2018
		US 2019196472 A1	27-06-2019
		WO 2018041591 A1	08-03-2018

DE 102018111070 A1	14-11-2019	CN 112088117 A	15-12-2020
		DE 102018111070 A1	14-11-2019
		WO 2019215222 A1	14-11-2019

DE 102019110925 A1	14-11-2019	CN 110466534 A	19-11-2019
		DE 102019110925 A1	14-11-2019
		US 2019344797 A1	14-11-2019
