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(54) Title: AUTOMATIC IDENTIFICATION OF AN EGO LANE AND ADAPTION OF A DRIVING TRAJECTORY FOR AN EGO VEHICLE DEPENDING ON THE EGO LANE

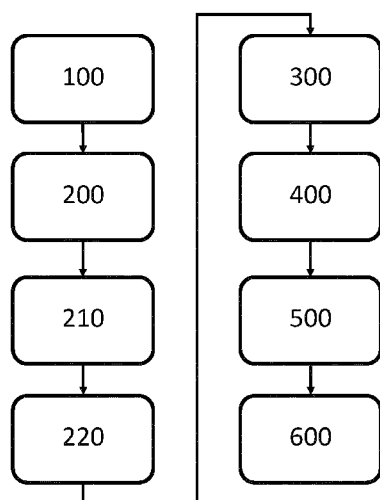


Fig. 1

(57) Abstract: The present invention refers to a method for a driving strategy of an ego vehicle on a road with an ego lane, wherein the road comprises at least a first driving lane and a second driving lane; the method comprising the steps of: assigning the ego vehicle to its driving lane as the ego lane (300); evaluating a driving scene for the ego lane based on at least the environmental information (400); determining a driving strategy based on the driving scene (500); and carrying out at least one operation according to the driving strategy (600) by an internal system of the ego vehicle. The present invention also refers to a computer program and a computer readable storage medium. Furthermore, the invention refers to a system comprising means for carrying out the steps of the method according to the invention. Moreover, the invention refers to an internal system of the ego vehicle, an ego vehicle comprising the internal system and a signal for the transmission in one of the steps of the method according to the invention.

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Automatic identification of an ego lane and adaption of a driving trajectory for an ego vehicle depending on the ego lane

The present invention refers to a method for a driving strategy of an ego vehicle on a road with an ego lane. The present invention also refers to a computer program and a computer readable storage medium.

Furthermore, the invention refers to a system comprising means for carrying out the steps of the method according to the invention. Moreover, the invention refers to an internal system of the vehicle, a vehicle comprising the internal system and a signal for the transmission in one of the steps of the method according to the invention.

CN 107264531 A refers to a method providing measures of how to perform a lane change maneuver. US 6 385 536 B2 refers to a method for determining on which road the vehicle drives after passing a fork in order to correct the navigation system performance. This patent focuses on the fork use case. According to this document, the road of travelling shall be identified. US 8700251 B1 refers to a method of tracking vehicles and determining whether these vehicles perform different actions, such as comparing vehicle movements with a map.

During manual driving on a highway or a multilane road, driving behavior can vary based on which lane a driver drives the vehicle. In a route from position A to position B, the driver may drive at different speeds, may perform multiple lane changes to pass slower vehicles, may drive at constant speed, may respect speed limits, may take a highway exit or ignore the highway exit. This manual driving behavior is not yet implemented by Advanced Driver Assistance Systems (ADAS) of level 2 and 3 in a meaningful way for the driver. The aforementioned levels refer to the SAE levels of automation. Automation levels reach from level 0 to 5.

ADAS and methods of ADAS according to the prior art are on a semi- or highly-automated level. These are systems to help the driver in the driving process. They shall mainly increase car safety and more generally traffic safety as many accidents occur due to human error. Most road accidents occur due to human error. Advanced driver-assistance systems are systems developed to automate, adapt and enhance vehicle

systems for safety and more comfortable driving. The automated system which is provided by ADAS to the vehicle is proven to reduce road fatalities, by minimizing the human error. Safety features are designed to avoid collisions and accidents by offering technologies that alert the driver to potential problems, or to avoid collisions by implementing safeguards and taking over control of the vehicle. An increasing number of modern vehicles have advanced driver-assistance systems such as electronic stability control, anti-lock brakes, lane departure warning, adaptive cruise control and traction control. These systems rely on actual detections of sensing means, which are provided for the lane on which the vehicle is positioned. Furthermore, information is provided on surrounding vehicles, and/or traffic signs in order to determine how the ADAS should support driving operations of the vehicle.

The U.S Department of Transportation, National Highway Traffic Safety Administration (NHTSA), provided a standard classification system in 2013 which defined five different levels of automation, ranging from level 0 (no automation) to level 4 (full automation). Since then, the NHTSA updated their standards to be in line with the classification system defined by SAE International. SAE International defines six different levels of automation in their new standard of classification in document SAE J3016 that ranges from 0 (no automation) to 5 (full automation).

Level 0 includes no automation. The driver is in complete control of the ego vehicle and the system does not interfere with driving. Systems that may fall into this category are exemplary forward collision warning systems and lane departure warning systems.

Level 1 includes driver assistance. The driver is in control of the ego vehicle, but the system can modify the speed and steering direction of the vehicle. Systems that may fall into this category are exemplary adaptive cruise control and lane keep assist.

Level 2 includes partial automation. The driver must be able to control the ego vehicle if corrections are needed, but the driver is no longer in control of the speed and steering of the ego vehicle. Parking assistance is an example of a system that falls into this category.

Level 3 includes conditional automation. The system is in complete control of ego vehicle functions such as speed, steering, and monitoring the environment. A driver must be ready to intervene, when requested by the system to do so.

Level 4 includes high automation. The system is in complete control of the ego vehicle and human presence is no longer needed, but its applications are limited to specific conditions.

Level 5 includes full automation. The system is in complete control of the ego vehicle and human presence is no longer needed. The system can provide the same aspects of a level 4, but the system can adapt to driving conditions.

However, the behavior of systems according to the prior art is, in most cases, similar regardless of which lane the vehicle drives. Even most advanced systems, which have access to navigation and map information, cannot derive exact localization information from which the system can identify on which lane the vehicle drives.

Hence, even if a system receives information that, in a certain distance ahead, the layout of the road changes, malfunctions of the system occur, such as choosing a driving lane, such as a highway exit, which is not intended to be chosen by the driver or a navigation system.

It is an object of the present invention to provide an improved method for an ADAS and an improved system for an ADAS. In particular, it is an object of the present invention to provide a method for an ADAS and a system for an ADAS for identifying a lane and a driving scene.

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 a driving strategy of an ego vehicle on a road with an ego lane, wherein the road comprises at least a first driving lane and a second driving lane. The method comprises the steps of: detecting environmental information about the road with at least one sensing means, wherein the environmental information comprises at least one detected object around the ego

vehicle; determining different driving lanes by providing a number of the driving lanes of the road and determining at least a first driving lane and a second driving lane; assigning the ego vehicle to its driving lane as the ego lane; evaluating a driving scene for the ego lane based on at least the environmental information; determining a driving strategy based on the driving scene; and carrying out at least one operation according to the driving strategy by an internal system of the ego vehicle.

In the context of this application, a driving lane, which may be the first driving lane or the second driving lane, is defined as the area between two lines, that means the area between two lane markers. The two lines may be a left line extending along a left side of the area in direction of movement of the ego vehicle and a right line extending along a right side of the area in direction of movement of the ego vehicle. A vehicle can be assigned to a driving lane. The driving lane, on which the ego vehicle drives, is defined as the ego lane comprising the closest left and right lines with respect to the position of vehicle.

Preferably, the step of determining different driving lanes by providing a number of the driving lanes of the road and determining at least a first driving lane and a second driving lane is executed by using the environmental information. In principle, the use of environmental information data alone or in combination with data already stored, such as a navigation system, is suitable as an example.

The present invention also provides a computer program comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the method according to the invention or according to a modified embodiment of the invention. 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 computer readable storage medium comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the method according to the invention or according to a modified embodiment of the invention.

The present invention also provides a system comprising means for carrying out the steps of the method according to the invention or according to a modified embodiment of the invention.

The present invention also provides an internal system of the vehicle comprising means for carrying out steps of the method according to the invention or according to a modified embodiment of the invention.

The present invention also provides a vehicle comprising the internal system according to the invention or according to a modified embodiment of the invention.

The present invention also provides a signal for the transmission in one of the steps of the method according to the invention or according to a modified embodiment of the invention.

The basic idea of the invention is identifying the scene type and the situation around the vehicle. The driver assistant system can take relevant measures at a much earlier stage in order to execute smooth, comfortable and safe driving operations in a better way, particularly in a driving scene, in which the course of the road changes. However, according to the method, it is not necessary to detect at least two driving lanes. It is only necessary that different driving lanes are identified based on the features of the environment which have been detected and identified.

For example, when the system obtains the information that a highway exit (HWE) is ahead and according to the selected navigation route the vehicle shall continue driving straight, according to the method is provided that different driving strategies may be applied depending on whether the vehicle drives on the left lane or the right lane or a center lane between the left lane and the right lane. For example, in case that the vehicle is on the left lane or the center lane, the HWE may be irrelevant. In case that the vehicle is on the right lane, the HWE may be relevant and the vehicle may be controlled to perform according driving operations or it may be provided that it is avoided that the vehicle is unintendedly controlled to drive towards the HWE.

According to a modified embodiment of the invention, the at least one object of the environmental information comprises at least one of: a road boundary, a lane boundary, and/or another vehicle on the road, wherein the other vehicle is in an environment of the ego vehicle. Sensing means for detecting such objects may be specifically configured to detect the kind of objects.

According to a modified embodiment of the invention, the step of assigning the ego vehicle to its driving lane as the ego lane comprises assigning the ego vehicle to the first driving lane and the second driving lane of the road. This may be an exemplary step of the method in case that the driving lanes are not automatically assigned to a specific road.

According to a modified embodiment of the invention, the operation according to the driving strategy is a driving operation. According to a modified embodiment of the invention, the operation according to the driving strategy comprises at least one of the following operations: reducing or increasing a speed of the ego vehicle, maintaining the speed of the ego vehicle, requesting for a change of the driving lane, triggering a specific lane handling logic, triggering shifting in driving lane, continuing driving on the ego lane, ignoring information provided by a navigation system, or driving on the road provided by the navigation system and ignoring a highway exit. Thus, adequate reactions on specific driving scenes are possible.

According to a modified embodiment of the invention, the specific lane handling logic comprises a lane handling logic for a splitting lane or a lane handling logic for a merging lane.

According to a modified embodiment of the invention, the at least one sensing means is comprised by the ego vehicle. This allows providing information without the need of data exchange between an external system and the vehicle, which provides the information.

According to a modified embodiment of the invention, the at least one object is at least one of: a guardrail, a barrier, or a lane marker. This provides the advantage that the sensing means can be trained on sensing specific features which the objects in the

target area usually have, such as being constructed of a certain material with a specific reflectivity.

According to a modified embodiment of the invention, the number of the driving lanes of the road is provided by a navigation system and/or by a digital map. Providing the number of driving lanes by maps or navigation systems may be additionally carried out to providing information on the number of lanes by sensing means in order to verify data provided by the sensing means.

According to a modified embodiment of the invention, the step of determining at least the first driving lane and the second driving lane comprises identifying at least the first driving lane and the second driving lane based on the environmental information and the number of the driving lane of the road. This improves identifying the lane on which the vehicle drives.

According to a modified embodiment of the invention, the step of determining at least the first driving lane and the second driving lane comprises identifying all the driving lanes of the road based on the environmental information and the number of the driving lanes of the road. This further improves identifying the lane on which the vehicle drives.

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 Shows a flow chart of an embodiment of a method according to the invention,
- Fig. 2 shows a schematic view of a first situation for a vehicle,
- Fig. 3 shows a schematic view of a second situation for the vehicle,
- Fig. 4 shows a schematic view of a third situation for the vehicle, and
- Fig. 5 shows a schematic view of a fourth situation for the vehicle.

The method will be described with reference to Figures 1 and 2. Figure 1 shows a flow chart of an embodiment of the method according to the invention.

Figure 2 shows a schematic view of a first situation for an ego vehicle 3. The road 2 comprises a first driving lane 1a, a second driving lane 1b and a third driving lane 1c. There is no need to say that the route 2 may comprise more or less driving lanes 1a, 1b, 1c. According to Figure 2, the route is a splitting lane 7. Between the right lane of a main route and a highway exit 8, a lane marking, for example provided by lane markers 6, is missing.

The method according to the invention is appropriate for identifying the ego lane 1 of the previously-described road 2 and for adapting a driving trajectory for the ego vehicle 3 depending on the ego lane 1. The ego lane 1 is one of the first, second or third driving lanes 1a, 1b, 1c, on which the ego vehicle 3 is positioned.

The method comprises the following steps, wherein the following steps may be carried out in a variable order or specific steps may be carried out simultaneously.

A step of detecting environmental information (indicated by the reference sign "100" in Figure 1) about the road 2 with at least one sensing means is provided. The environmental information comprises at least one detected object around the ego vehicle 3. The at least one detected object is specified below.

The method further comprises a step of determining different driving lanes 1a, 1b, 1c (indicated by the reference sign "200" in Figure 1). This step is carried out by providing a number of the driving lanes 1a, 1b, 1c of the road 2 (indicated by the reference sign "210" in Figure 1) and determining at least a first driving lane 1a and a second driving lane 1b (indicated by the reference sign "220" in Figure 1). In the present case, three driving lanes 1a, 1b, 1c are determined. Preferably, the step of determining different driving lanes 1a, 1b, 1c (indicated by the reference sign "200" in Figure 1) by providing a number of the driving lanes 1a, 1b, 1c of the road 2 (indicated by the reference sign "210" in Figure 1) and determining at least a first driving lane 1a and a second driving lane 1b (indicated by the reference sign "220" in Figure 1) is executed by using the environmental information. In principle, the use of environmental information data alone

or in combination with data already stored, such as a navigation system, is suitable as an example.

Further, the method comprises assigning the ego vehicle 3 to its driving lane 1a, 1b, 1c as the ego lane 1 (indicated by the reference sign "300" in Figure 1).

Furthermore, it is provided a step of evaluating a driving scene for the ego lane 1 based on at least the environmental information (indicated by the reference sign "400" in Figure 1). Moreover, it is provided a step of determining a driving strategy based on the driving scene (indicated by the reference sign "500" in Figure 1) and a step of carrying out at least one operation according to the driving strategy (indicated by the reference sign "600" in Figure 1) by an internal system of the ego vehicle 3.

The at least one object of the environmental information comprises at least one of: a road boundary 4, a lane boundary 5, and/or another vehicle on the road 2. The other vehicle is in an environment of the ego vehicle 3.

The step of assigning the ego vehicle 3 to its driving lane 1a, 1b, 1c as the ego lane 1 comprises assigning the ego vehicle 3 to the first driving lane 1a and the second driving lane 1b and the third driving lane 1c of the road 2.

The operation according to the driving strategy is a driving operation. The operation according to the driving strategy comprises at least one of the following operations: reducing or increasing a speed of the ego vehicle 3, maintaining the speed of the ego vehicle 3, requesting for a change of the driving lane 1a, 1b, 1c, triggering a specific lane handling logic, triggering shifting in driving lane 1a, 1b, 1c, continuing driving on the ego lane 1, ignoring information provided by a navigation system, or driving on the road 2 provided by the navigation system and ignoring a highway exit. The specific lane handling logic comprises a lane handling logic for a splitting lane 7 (see Figures 2 to 4) or a lane handling logic for a merging lane.

The at least one sensing means is comprised by the ego vehicle 3.

The at least one object is at least one of: a guardrail, a barrier, or a lane marker 6.

The number of the driving lanes 1a, 1b, 1c of the road 2 is provided by a navigation system and/or by a digital map.

The step of determining at least the first driving lane 1a and the second driving lane 1b comprises identifying at least the first driving lane 1a and the second driving lane 1b and the third driving lane 1c based on the environmental information and the number of the driving lanes 1a, 1b, 1c of the road 2. Alternatively, or additionally, the step of determining at least the first driving lane 1a and the second driving lane 1b comprises identifying all the driving lanes 1a, 1b, 1c of the road 2 based on the environmental information and the number of the driving lanes 1a, 1b, 1c of the road 2.

In Figures 3 to 5, different situations are shown. In the situation according to Figure 3, the ego vehicle 3 is on the first driving lane 1a, which is the left driving lane. In such a case, the method according to the invention may provide a driving strategy being configured such that the ego vehicle 3 continues driving on the left driving lane and/or increases the speed of the ego vehicle 3 while respecting the speed limit. In the situation according to Figure 4, the ego vehicle 3 is on the second driving lane 1b, which is the center driving lane. In such a case, the method according to the invention may provide a driving strategy being configured such that the ego vehicle 3 continues driving on the center driving lane. In the situation according to Figure 5, the ego vehicle 3 is on the third driving lane 1c, which is the right driving lane. In such a case, the method according to the invention may provide a driving strategy being configured such that the ego vehicle 3 may prepare to avoid the highway exit, in case that the navigation system suggests driving straight and not to take the highway exit. Furthermore, the driving strategy may be configured such that the ego vehicle 3 is controlled to prepare slowing down and shift to a left lane of the current lane, since a vehicle ahead, being a potential obstacle ahead, may take the highway exit.

The invention also refers to a computer program comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the previously described method. The invention also refers to a computer readable storage medium comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the previously described method.

Furthermore, the invention refers to a system (not depicted) comprising means for carrying out the steps of the previously described method. The invention also comprises an internal system (not depicted) of the ego vehicle 3 comprising means for carrying out steps of the previously described method. Furthermore, the invention refers to an ego vehicle 3 comprising the internal system. Finally, the invention refers to a signal for the transmission in one of the steps of the method as previously described.

Reference signs list

- 1 ego lane
- 1a first driving lane
- 1b second driving lane
- 1c third driving lane
- 2 road
- 3 ego vehicle
- 4 road boundary
- 5 lane boundary
- 6 lane marker
- 7 splitting lane
- 8 highway exit

- 100 detecting environmental information about the road
- 200 determining different driving lanes
- 210 by providing a number of the driving lanes of the road
- 220 determining at least a first driving lane and a second driving lane
- 300 assigning the ego vehicle to its driving lane as the ego lane
- 400 evaluating a driving scene for the ego lane based on at least the environmental information
- 500 determining a driving strategy based on the driving scene
- 600 carrying out at least one operation according to the driving strategy

Patent claims

1. Method for a driving strategy of an ego vehicle (3) on a road (2) with an ego lane (1),
wherein the road (2) comprises at least a first driving lane (1a) and a second driving lane (1b); the method comprising the steps of:
 - detecting environmental information (100) about the road (2) with at least one sensing means, wherein the environmental information comprises at least one detected object around the ego vehicle (3);
 - determining different driving lanes (1a, 1b) (200) by providing a number of the driving lanes (1a, 1b) of the road (2) (210) and determining at least a first driving lane (1a) and a second driving lane (1b) (220);
 - assigning the ego vehicle (3) to its driving lane (1a, 1b) as the ego lane (1) (300);
 - evaluating a driving scene for the ego lane (1) based on at least the environmental information (400);
 - determining a driving strategy based on the driving scene (500); and
 - carrying out at least one operation according to the driving strategy (600) by an internal system of the ego vehicle (3).
2. Method according to claim 1, wherein the at least one object of the environmental information comprises at least one of: a road boundary (4), a lane boundary (5), and/or another vehicle on the road (2), wherein the other vehicle is in an environment of the ego vehicle (3).
3. Method according to claim 1 or 2, wherein the step of assigning the ego vehicle (3) to its driving lane (1a, 1b) as the ego lane (1) (300) comprises assigning the ego vehicle (3) to the first driving lane (1a) and the second driving lane (1b) of the road (2).
4. Method according to any one of the preceding claims, wherein the operation according to the driving strategy is a driving operation.

5. Method according to any one of the preceding claims, wherein the operation according to the driving strategy comprises at least one of the following operations: reducing or increasing a speed of the ego vehicle (3), maintaining the speed of the ego vehicle (3), requesting for a change of the driving lane (1a, 1b), triggering a specific lane handling logic, triggering shifting in driving lane (1a, 1b), continuing driving on the ego lane (1), ignoring information provided by a navigation system, or driving on the road (2) provided by the navigation system and ignoring a highway exit.
6. Method of claim 5, wherein the specific lane handling logic comprises a lane handling logic for a splitting lane (7) or a lane handling logic for a merging lane.
7. Method according to any one of the preceding claims, wherein the at least one sensing means is comprised by the ego vehicle (3).
8. Method of any one of the preceding claims, wherein the at least one object is at least one of: a guardrail, a barrier, or a lane marker (6).
9. Method of any one of the preceding claims, wherein the number of the driving lanes (1a, 1b) of the road (2) is provided by a navigation system and/or by a digital map.
10. Method of any one of the preceding claims, wherein the step of determining at least the first driving lane (1a) and the second driving lane (1b) (220) comprises identifying at least the first driving lane (1a) and the second driving lane (1b) based on the environmental information and the number of the driving lanes (1a, 1b) of the road (2).
11. Method of any one of the preceding claims, wherein the step of determining at least the first driving lane (1a) and the second driving lane (1b) (220) comprises identifying all the driving lanes (1a, 1b) of the road (2) based on the environmental information and the number of the driving lanes (1a, 1b) of the road (2).
12. Computer program comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the method of any one of claims 1 to 11.

13. Computer readable storage medium comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the method of any one of claims 1 to 11.
14. System comprising means for carrying out the steps of the method of any one of claims 1 to 11.
15. Internal system of the ego vehicle (3) comprising means for carrying out steps of the method of any one of claims 1 to 11.
16. Ego vehicle (3) comprising the internal system according to claim 15.
17. Signal for the transmission in one of the steps of the method of any one of claims 1 to 11.

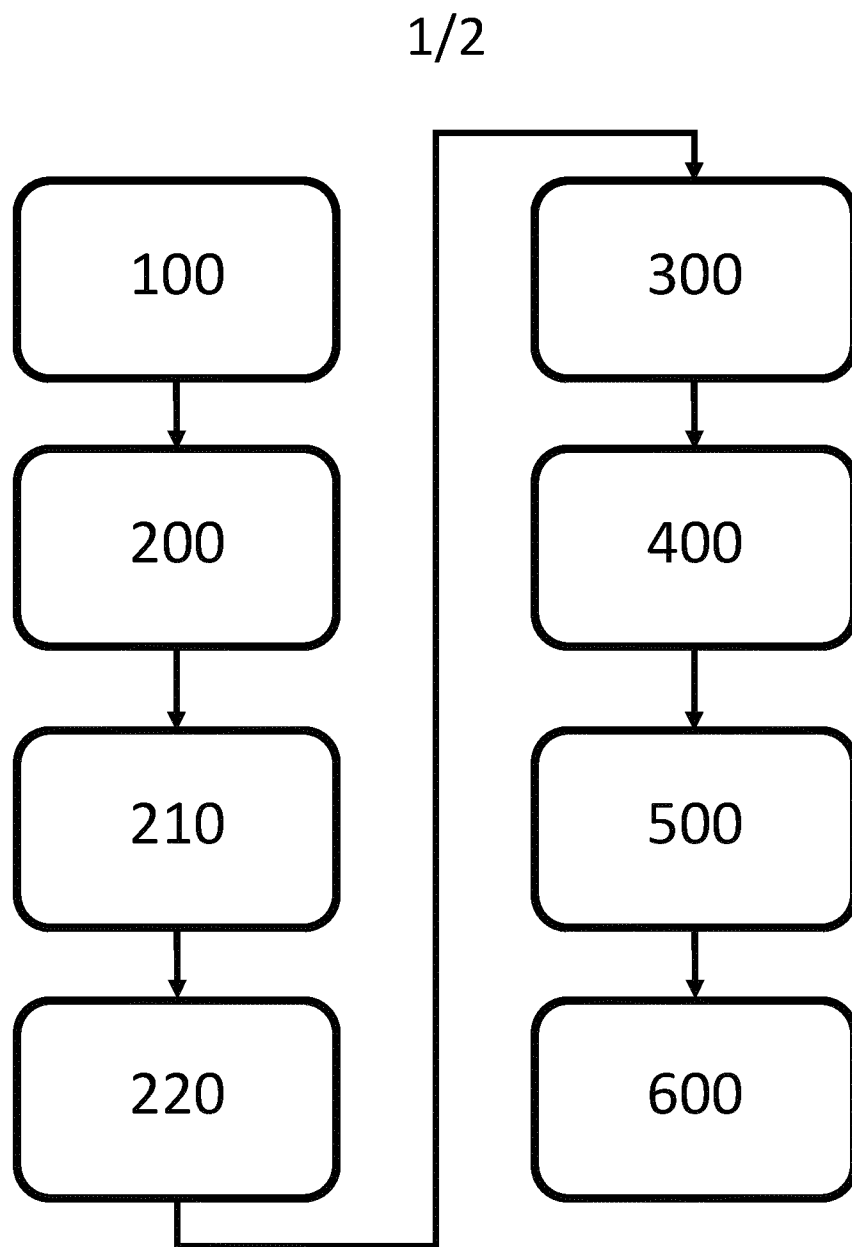
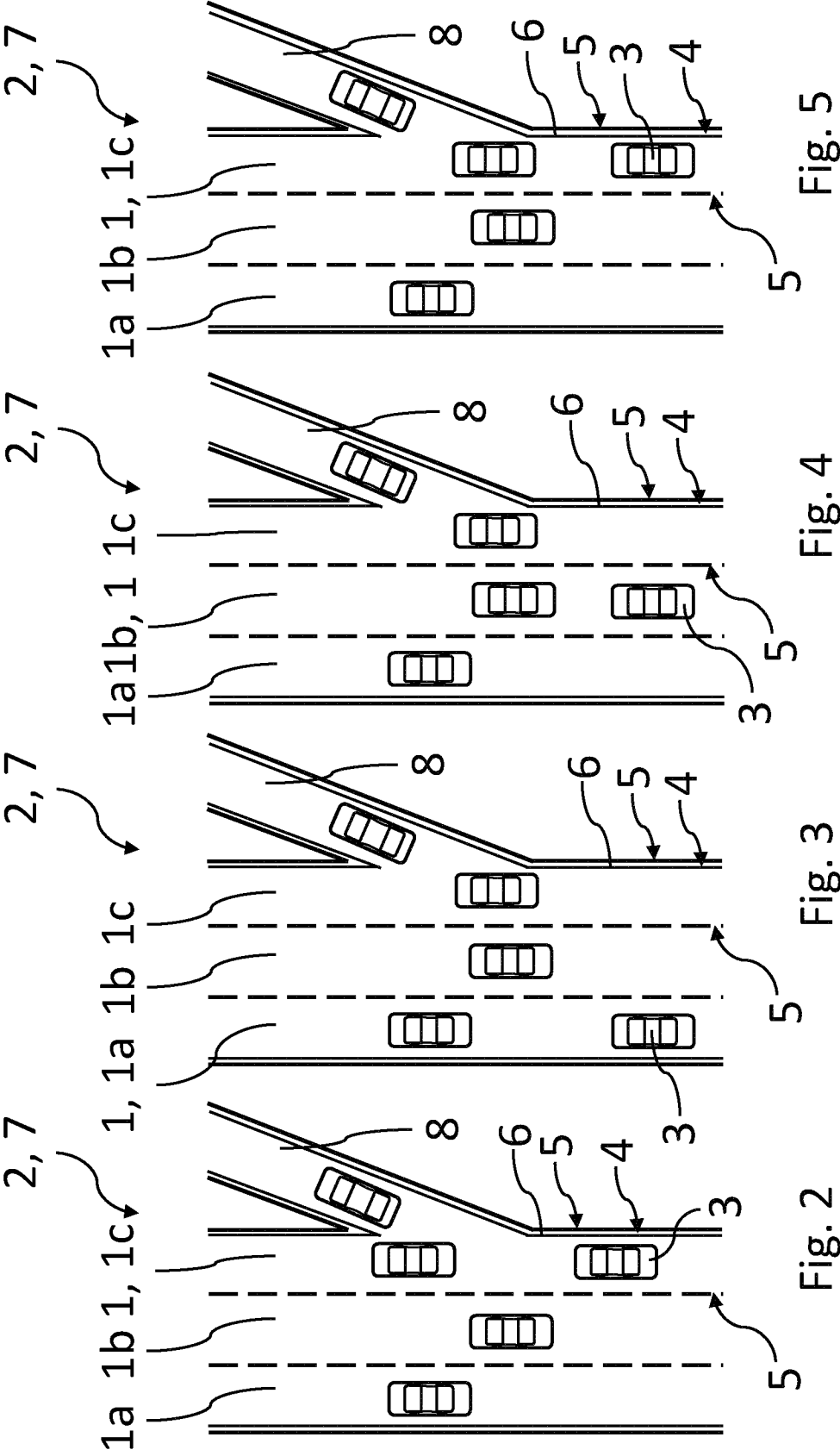


Fig. 1



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/064494

A. CLASSIFICATION OF SUBJECT MATTER INV. G01C21/36 B60W30/08 B60W60/00 G05D1/00 G05D1/02 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) G01C G05D B60W G08G														
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 <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>US 2017/336788 A1 (IAGNEMMA KARL [US]) 23 November 2017 (2017-11-23) paragraphs [5379], [0084], [0085], [0111], [0116]; figures 5,9 -----</td> <td>1-17</td> </tr> <tr> <td>X</td> <td>DE 10 2004 057060 A1 (DAIMLER CHRYSLER AG [DE]) 8 June 2006 (2006-06-08) paragraphs [0009], [0011], [0016] - [0020] -----</td> <td>1-17</td> </tr> <tr> <td>X</td> <td>US 2015/321665 A1 (PANDITA ROHIT [US] ET AL) 12 November 2015 (2015-11-12) paragraphs [0009], [0035], [0036], [0062]; figures 1,2 ----- -/-</td> <td>1-17</td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	US 2017/336788 A1 (IAGNEMMA KARL [US]) 23 November 2017 (2017-11-23) paragraphs [5379], [0084], [0085], [0111], [0116]; figures 5,9 -----	1-17	X	DE 10 2004 057060 A1 (DAIMLER CHRYSLER AG [DE]) 8 June 2006 (2006-06-08) paragraphs [0009], [0011], [0016] - [0020] -----	1-17	X	US 2015/321665 A1 (PANDITA ROHIT [US] ET AL) 12 November 2015 (2015-11-12) paragraphs [0009], [0035], [0036], [0062]; figures 1,2 ----- -/-	1-17
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X	US 2015/321665 A1 (PANDITA ROHIT [US] ET AL) 12 November 2015 (2015-11-12) paragraphs [0009], [0035], [0036], [0062]; figures 1,2 ----- -/-	1-17												
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.														
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2 September 2020		08/09/2020												
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