(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 002 320 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.05.2022 Bulletin 2022/21

(21) Application number: **20209394.4**

(22) Date of filing: **24.11.2020**

(51) International Patent Classification (IPC):
G08G 1/00 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
G08G 1/22

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Volvo Autonomous Solutions AB**
405 08 Göteborg (SE)

(72) Inventors:
- **WIBERG, Wilhelm**
  436 39 (SE)
- **BERGQUIST, Stefan**
  417 26 Göteborg (SE)

(74) Representative: **Valea AB**
Box 1098
405 23 Göteborg (SE)

(54) A METHOD FOR COOPERATIVE ADAPTIVE CRUISE CONTROL

(57) The invention provides to a method for Cooperative Adaptive Cruise Control (CACC) with vehicle-to-vehicle (V2V) communication, the method comprising
- a subject vehicle determining (S2), by means of a length determination procedure, an assumed length (Las) of a communicating vehicle travelling ahead of the subject vehicle,
- the method further comprising, if length information about the length (L1) of the communicating vehicle is available (S3) to the subject vehicle, the length information being obtained in a way that is different from said length determination procedure, the subject vehicle comparing (S4) the assumed length with the length according to the length information, and connecting (S5) to the communicating vehicle if the assumed length (Las) differs from the length (L1) according to the length information by less than a difference threshold value.

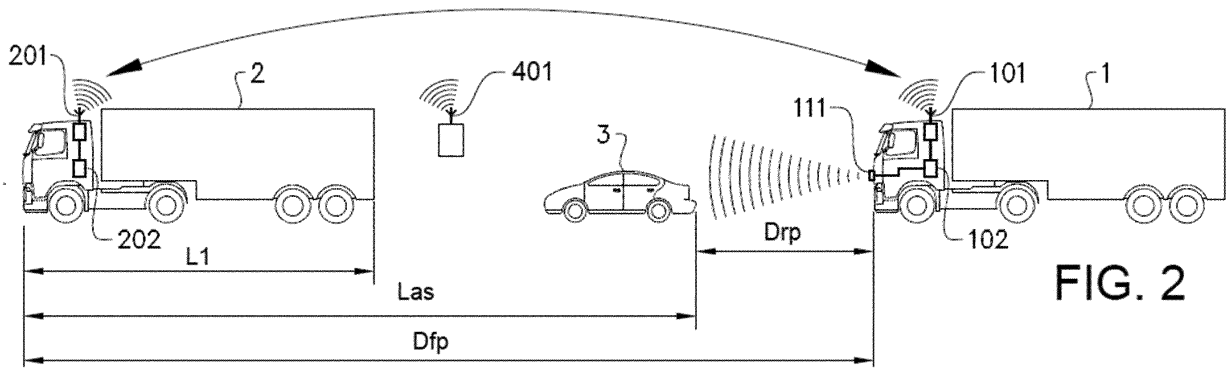


FIG. 2

EP 4 002 320 A1

Description

TECHNICAL FIELD

[0001] The invention relates to a method for Cooperative Adaptive Cruise Control (CACC) with vehicle-to-vehicle (V2V) communication. The invention also relates to a computer program, a computer readable medium, and a control unit, or a group of control units. The invention further relates to a vehicle comprising a control unit.

[0002] The invention can be applied in heavy-duty vehicles, such as trucks, and buses. Although the invention will be described with respect to a truck, the invention is not restricted to this particular vehicle, but may also be used in other vehicles such as cars.

BACKGROUND

[0003] In Cooperative Adaptive Cruise Control (CACC) and platooning, vehicle convoys are driven with short distances between the vehicles. To achieve this with a high safety, a control unit of each vehicle receives information from surrounding vehicles over a wireless communication channel, so called Vehicle-to-Vehicle (V2V) communication. This information is used in the control to keep the desired distance between each vehicle and the immediately preceding vehicle and to handle events such as hard braking. The V2V communication enables keeping short distances safely since the V2V information is transferred faster, or much faster, and is more accurate than data from on-board sensors such as radar sensors, laser sensors or cameras.

[0004] Benefits with CACC and platooning include increased fuel efficiency, provided by a reduced air-drag due to short distances between vehicles, and provided by improved vehicle control due to more accurate information about the preceding vehicle. A further benefit is an improved traffic flow due to the small delay of the V2V data. Yet another benefit with CACC and platooning is an improved driver comfort since CACC allows less aggressive vehicle control compared to systems using on-board sensors exclusively.

[0005] For a platooning process, it may be of interest for a subject vehicle to know the length of a vehicle travelling ahead of the subject vehicle. WO13187834 suggests that the respective locations of platooning vehicles are known from GPS positions, and a rearward vehicle uses radar to measure the distance to a vehicle in front of the rearward vehicle. The length of the forward vehicle is determined by subtracting the radar measured distance from the distance between the GPS positions.

[0006] However, there is still a desire to allow simple procedures for platooning, while keeping a high level of safety.

SUMMARY

[0007] An object of the invention is to facilitate a fast and reliable determination of a subject vehicle whether to connect to another vehicle for platooning.

[0008] The object is reached by a method according to claim 1. Thus, the object is reached with a method for Cooperative Adaptive Cruise Control (CACC) with vehicle-to-vehicle (V2V) communication, the method comprising

- a subject vehicle determining, by means of a length determination procedure, an assumed length of a communicating vehicle travelling ahead of the subject vehicle,
- the method further comprising, if length information about the length of the communicating vehicle is available to the subject vehicle, the length information being obtained in a way that is different from said length determination procedure, the subject vehicle comparing the assumed length with the length according to the length information, and connecting to the communicating vehicle if the assumed length differs from the length according to the length information by less than a difference threshold value.

[0009] The method may comprise the subject vehicle detecting the communicating vehicle, e.g. by means of wireless V2V communication. The communicating vehicle may have data identifying the communicating vehicle, which data is shared over the V2V communication.

[0010] The subject vehicle may detect the communicating vehicle by means of the shared data identifying the communicating vehicle.

[0011] Said length information may, or may not, be available to the subject vehicle, e.g. to a control unit thereof. If available, the subject vehicle, e.g. a control unit thereof, may compare the assumed length with the length according to the length information. The difference threshold value may be predetermined, or calculated according to a predetermined algorithm. The difference threshold value may be a negligible value of a vehicle length parameter. In some embodiments, the difference threshold value may be zero; thereby, the condition for establishing a connection may be that the assumed length is the same as the length according to the length information.

[0012] The method may comprise the subject vehicle determining whether to connect to the communicating vehicle. The determination whether to connect to the communicating vehicle may be done by a control unit of the subject vehicle. If a connection is established, the subject vehicle may travel behind the communicating vehicle, and receive, from the communicating vehicle, wireless signals, e.g. V2V signals, representative of the velocity and/or acceleration of the communicating vehicle. Thereby, the subject vehicle may control the velocity and/or acceleration of the subject vehicle in dependence on the received signals. It should be noted that the received signals may also be representative of one or more further conditions of the communicating vehicle, and/or one or more conditions which affect, or may affect, the operation of the communicating vehicle. Such further conditions may include a road inclination, e.g. at the position of the communicating vehicle, an intended or predicted acceleration of the communicating vehicle, and/or a distance between the communicating vehicle and a vehicle in front of the communicating vehicle, e.g. as determined by means of one or more sensors of the communicating vehicle. Thus, the velocity and/or acceleration of the subject vehicle may be controlled in dependence on such further conditions, in addition to the velocity and/or acceleration of the communicating vehicle.

[0013] The invention allows, for establishing a connection for platooning with CACC, the subject vehicle verifying that the preceding vehicle detected by one or more sensors of the subject vehicle, matches a vehicle identified with the V2V communication, i.e. the communicating vehicle. The invention provides a way to easily confirm whether the assumed length is the actual length of the communicating vehicle. For example, if confirmed, the possibility of a further vehicle being present between the communicating vehicle and the subject vehicle, may be excluded. The connection determination process may be made only with V2V data, and one or more sensors of the subject vehicle. Thereby, the invention provides a simple and reliable connection determination procedure. Thus, the invention enables fast and safe connection processes based on vehicle length estimations.

[0014] The length information may be obtained by retrieving the length information from a database. Advantageously, as exemplified below, the stored length information may be an assumed length determined by means of a length determination procedure executed at a connection determination procedure at an occasion in the past, whereupon the assumed length determined in the past was stored. In case the length information from the database, with the assumed length determined in the past, matches the assumed length determined at present, it may be safely and quickly determined that the subject vehicle can connect to the communicating vehicle.

[0015] In some embodiments, the length information may be obtained by receiving the length information from the communicating vehicle by the V2V communication. In case the length information from the communicating vehicle matches the assumed length, it may be safely and quickly determined that the subject vehicle can connect to the communicating vehicle.

[0016] Preferably, the length determination procedure comprises determining a rear portion distance, the rear portion distance being a distance between the subject vehicle and a rear portion of a vehicle in front of the subject vehicle, determining a front portion distance, the front portion distance being a distance between the subject vehicle and a front portion of the communicating vehicle, and determining the assumed length in dependence on the rear portion distance and the front portion distance. Thereby, the assumed length may be determined in a fast and simple manner.

[0017] The rear portion distance may be determined by means of one or more sensors of the subject vehicle. The rear portion distance may be a distance between the subject vehicle and a rear portion of a vehicle immediately in front of the subject vehicle. The position of the front portion of the communicating vehicle may be sent from the communicating vehicle with the V2V communication. The front portion distance may be determined in dependence on a communicated position obtained by GNSS (Global Navigation Satellite System), e.g. GPS (Global Positioning System). The position of the subject vehicle may also be obtained by GNSS. The communicating vehicle and subject vehicle may both have a positioning device using GNSS located in the front part of the respective vehicle, e.g. in a cab of the respective vehicle. Therefore, the front portion distance may be a distance between a front portion of the subject vehicle and the front portion of the communicating vehicle. Thereby, the assumed length may be determined in a fast and simple manner, using merely V2V and sensor data.

[0018] Preferably, the method comprises, if the assumed length differs from the length according to the length information by more than the difference threshold value, performing a target identification procedure to determine whether the vehicle in front of the subject vehicle is the communicating vehicle. This is advantageous in situations where information about the length of the communicating vehicle is not updated according to reality. For example, the communicating vehicle may share a vehicle length value that does not match its true one. In addition, or alternatively, a target identification procedure may be performed if the length information is not available to the subject vehicle.

[0019] The target identification procedure may comprise the subject vehicle requesting with the V2V communication the that the communicating vehicle performs an action. The request of the subject vehicle may instruct the communicating vehicle to perform the action. The subject vehicle may determine that the vehicle in front is the communicating vehicle if the subject vehicle detects that the vehicle in front performs the action. Upon such a detection, the communicating vehicle may be safely determined as the vehicle immediately in front of the subject vehicle. The action may for example be flashing a rear light of the communicating vehicle. The detection may be made by means of a sensor, such as a camera, of the subject vehicle. The detection may be made by means of an image processing software analyzing signals from a camera of the subject vehicle.

[0020] If the subject vehicle determines that the vehicle detected by the sensor did not perform said action, the subject vehicle may determine that the communicating vehicle and the vehicle detected by the sensor are not the same vehicle. Thereby, the method may comprise, if it is determined by the performed target identification procedure that the vehicle in front of the subject vehicle is not the communicating vehicle, the subject vehicle determining to not connect to the communicating vehicle.

[0021] If the subject vehicle determines that the vehicle detected by the sensor performed said action, the subject vehicle may determine that the communicating vehicle and the vehicle detected by the sensor are the same vehicle. Thereby, if it is determined by the performed target identification procedure that the vehicle in front of the subject vehicle is the communicating vehicle, the subject vehicle may connect to the communicating vehicle.

[0022] Preferably, if it is determined by the performed target identification procedure that the vehicle in front of the subject vehicle is the communicating vehicle, the assumed length is stored in a database. Thereby, the stored assumed length may be coordinated with stored data identifying the communicating vehicle. Thereby, accurate information of the length of the communicating vehicle may be saved for future purposes. Also, obsolete information of the length of the communicating vehicle may be updated. Thereby, future platoon connection procedures may be facilitated. More specifically, in case, at a connection determination procedure in a future occasion, no length information is shared by the communicating vehicle, the subject vehicle could compare an assumed length determined at the future occasion by means of a length determination procedure, e.g. as exemplified above, with the stored assumed length. Thereby, the subject vehicle could obtain a quick and simple connection determination procedure. Such a comparison could also be made in case, at a connection determination procedure in a future occasion, the length information shared by the communicating vehicle is not correct.

[0023] The assumed length may be stored in the database by the subject vehicle. The database may be located in the subject vehicle. Alternatively, the database may be remotely located. The database may have data storing processing functions, and communication functions. Thereby, the subject vehicle may send, e.g. wirelessly, the assumed length to the database, whereupon the assumed length is stored in the database, coordinated with data identifying the communicating vehicle.

[0024] The stored assumed length, coordinated with data identifying the communicating vehicle, may be shared with a further vehicle, or a plurality of further vehicles. Where the assumed length is stored in a database, the further vehicle may send, e.g. wirelessly, with data identifying the communicating vehicle, a request to the database, for information on the length of the communicating vehicle. The database may share the assumed length by sending, e.g. wirelessly, the assumed length to the further vehicle. The database may send the assumed length to the further vehicle in response to the request by the further vehicle. Thereby, if the further vehicle is in a process of determining whether to connect to the communicating vehicle, and thereby no length information is shared by the communicating vehicle, the further vehicle could compare an assumed length determined by the further vehicle by means of a length determination procedure, e.g. as exemplified above, with the shared assumed length. Thereby, the further vehicle could obtain a quick and simple connection determination procedure.

[0025] Preferably, the method comprises registering a time at which the assumed length was determined by means of the length determination procedure, wherein storing the assumed length in the database comprises storing in the database the time at which the assumed length was determined. The communicating vehicle may be a truck with a trailer. Thereby, the communicating vehicle may be able to change trailer after the determination of the assumed length. Thereby, since the trailers may differ in length, the length of the communicating vehicle may become unknown when the trailer is changed. Therefore, the assumed length may be valid only until the communicating vehicle changes trailer. Therefore, the method may comprise using, in a future process for determining whether to connect to the communicating vehicle, the stored assumed length as length information obtained from the database, only if a time interval, from the time at which the assumed length was determined to the time of said future connection determination process, is shorter than a threshold time interval. The threshold time interval may be predetermined, or calculated according to a predetermined algorithm.

[0026] The method may comprise registering a position at which the assumed length was determined by means of the length determination procedure, wherein storing the assumed length in the database comprises storing in the database the position at which the assumed length was determined. If the communicating vehicle is detected by the subject vehicle a plurality of times while the subject vehicle is driving along a road, such as a highway, it may be assumed that the communicating vehicle has not changed trailer in between two of the detections. However, if the stored assumed length is shared with a further vehicle, the stored position at which the assumed length was determined, and optionally the stored time at which the assumed length was determined, will assist in making an assumption on whether the communicating vehicle has not changed trailer since the determination of the stored assumed length. In some embodiments, if, in a future process for determining whether to connect to the communicating vehicle, the stored assumed length is provided to the subject vehicle, or shared with a further vehicle, together with the time and position at which the assumed length was determined, the average speed of the communicating vehicle, between the determination of the assumed length and the future connection determination process, may be determined. Based on said average speed of the communicating vehicle, an assumption may be made on whether the communicating vehicle has changed trailer since the determination of the stored assumed length. It is understood that said average speed may be determined in dependence on the time and position of the future connection determination process, and possibly map data, in addition to the time and position of the assumed length determination. In some embodiments, it may be determined that the communicating vehicle has not changed trailer since the determination of the stored assumed length, if the average speed is above an average speed threshold value. Thereby, use is made of an assumption that the communicating vehicle changing trailer will require the communicating vehicle to stop, and time to be consumed by a trailer change procedure, which will reduce said average speed. The average speed threshold value may be predetermined, or calculated according to a predetermined algorithm.

[0027] The object is also reached with a method for Cooperative Adaptive Cruise Control (CACC) with vehicle-to-vehicle (V2V) communication, the method comprising

- determining a rear portion distance, the rear portion distance being a distance between a subject vehicle and a rear portion of a vehicle in front of the subject vehicle, determining a front portion distance, the front portion distance being a distance between the subject vehicle and a front portion of a communicating vehicle travelling ahead of the subject vehicle, and determining an assumed length of the communicating vehicle in dependence on the rear portion distance and the front portion distance,
- the method further comprising the subject vehicle requesting, with the V2V communication, that the communicating vehicle performs an action, and
- the subject vehicle connecting to the communicating vehicle if the subject vehicle detects that the vehicle in front performs the action.

[0028] The steps of determining a rear portion distance, determining a front portion distance, and determining an assumed length of the communicating vehicle, may be performed by the subject vehicle, e.g. by a control unit thereof. Said steps of determining a rear portion distance, determining a front portion distance, and determining an assumed length of the communicating vehicle, may form an embodiment of what is herein referred to as a length determination procedure.

[0029] The method may comprise the subject vehicle requesting that the communicating vehicle performs an action, e.g. activating a turning signal, and the subject vehicle determining whether or not the vehicle in front performs the action. These steps may form an embodiment of what is herein referred to as a target identification procedure.

[0030] Thereby, if the subject vehicle detects that the vehicle in front performs the requested action, the subject vehicle can conclude that the vehicle in front is the communicating vehicle. Therefore, since the assumed length is determined using the distance between the subject vehicle and the rear portion of the vehicle in front of the subject vehicle, the subject vehicle can conclude that the assumed length is the length of the communicating vehicle. Thereby, the subject vehicle can exclude the possibility that the assumed length determination is incorrect due to a further vehicle being present between the subject vehicle and the communicating vehicle.

[0031] Upon detecting that the vehicle in front performs the action, the assumed length may be stored, e.g. by the subject vehicle, in a database. Thereby, if at a future occasion, the subject vehicle determines whether or not to connect to the communicating vehicle, the subject vehicle may receive data identifying the communicating vehicle, e.g. via V2V communication from the communicating vehicle. Using this identifying data, the subject vehicle may at the future occasion retrieve the stored assumed length. Further, at the future occasion, the subject vehicle may perform a further length determination procedure. The further length determination procedure may provide a further assumed length of the communicating vehicle. Thereby, the stored assumed length may form length information about the length of the communicating vehicle, which is obtained in a way, i.e. a storage data retrieval, that is different from the further length determination procedure.

[0032] Thereby, the subject vehicle may compare the further assumed length with the length according to the length information, i.e. the stored assumed length. Thereby, the subject vehicle may, at the future occasion, connect to the communicating vehicle if the further assumed length differs from the length according to the length information by less than a difference threshold value.

[0033] Thus, by storing the assumed length, future connection determination processes, involving the same communicating vehicle, may be done in a simple and secure manner. In particular, the target identification procedure does not have to be repeated at the future occasion.

[0034] In addition, if at the target identification procedure the subject vehicle detects that the vehicle in front performs the action, the assumed length may be stored in a database, such that it is accessible to the subject vehicle, as well as one or more further vehicles, which may in the future execute a process for determining whether to connect to the communicating vehicle. Thereby, such a connection determination process may be done in a simple and secure manner, e.g. without the target identification procedure. Thus, the database storage may function as an update for an accurate value of the communicating vehicle length, to be used in future occasions, whether by the subject vehicle, or further vehicles.

[0035] If at the future occasion, the further assumed vehicle length differs from the stored assumed vehicle length by more than the difference threshold value, the target identification procedure may be executed.

[0036] The object is also reached with a computer program according to claim 15, a computer readable medium according to claim 16, a control unit according to claim 17, or a vehicle according to claim 18.

[0037] Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

[0039] In the drawings:

Fig. 1 is a side view of two vehicles during vehicle platooning.

Fig. 2 is a side view of the vehicles in fig. 1 with a further vehicle between them.

Fig. 3 is a block diagram depicting steps in a method according to an embodiment of the invention.

Fig. 4 is a block diagram depicting steps in a method according to a more general embodiment of the invention.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

[0040] Fig. 1 shows what is herein referred to as a subject vehicle 1 travelling along a road behind another vehicle, herein referred to as a communicating vehicle 2. In this example, the subject vehicle 1 as well as the communicating vehicle 2 are trucks with semitrailers. However, the invention is equally applicable to other types of vehicles, such as cars, buses and dump trucks.

[0041] Each of the subject vehicle 1 and the communicating vehicle 2 comprises equipment 101, 201 for Cooperative Adaptive Cruise Control (CACC), including means for wireless communication with a radio transmitter and a radio receiver for so called Vehicle-to-Vehicle (V2V) communication, and a data communication processing device which is arranged to communicate with a control unit 102, 202 of a respective vehicle control system. Thereby, each of the vehicles 1, 2 is adapted to transmit signals representative of the dimensions, velocity and acceleration of the respective vehicle to other vehicles comprising equipment for CACC. Further, each of the vehicles 1, 2 is adapted to receive signals representative of the dimensions, velocity and acceleration of other vehicles comprising equipment for CACC, and to control the velocity and acceleration of the respective vehicle based on the received signals. Thereby, the vehicles 1, 2 may be involved in a vehicle platooning process, in which the subject vehicle 1 is controlled to be at a relatively short distance from the communicating vehicle 2. Thus, the vehicle platooning process involves CACC with V2V communication.

[0042] The vehicle control system of the subject vehicle 1 controls brakes and a drivetrain of the subject vehicle 1 based on the wireless signals received from the communicating vehicle 2. For example, if the communicating vehicle 2 brakes hard, signals representing the resulting deceleration will be received by the subject vehicle 1 which will based thereupon brake hard as well. CACC will in such a situation allow a considerably faster response by the subject vehicle 1, compared to a vehicle control based on radar, laser or camera detection of the deceleration of the vehicle in front of the subject vehicle 1.

[0043] In addition to the equipment for CACC, the subject vehicle comprises a radar sensor 111 by means of which the presence of, and the distance to, an object in front of the subject vehicle 1 may be determined. The radar sensor 111 provides means in addition to the CACC equipment for controlling the subject vehicle 1 in relation to other vehicles. In alternative embodiments, the means in addition to the CACC equipment for controlling the subject vehicle 1 in relation to other vehicles, could be provided by a laser sensor or a camera.

[0044] In fig. 2, a further vehicle 3 is present between the subject vehicle 1 and the communicating vehicle 2. The further vehicle is in this example a car, but can of course be any other kind of vehicle, such as a truck or a bus. The further vehicle 3 may not have any equipment for CACC.

[0045] Reference is made also to fig. 3. For entering a platooning process with the communicating vehicle, the subject vehicle has to establish what is herein referred to as a connection with the communicating vehicle. Below an embodiment of a method according to the invention is described, comprising the subject vehicle 1 determining whether to connect to the communicating vehicle 2.

[0046] The method comprises the subject vehicle 1 detecting S1 the communicating vehicle 2 travelling ahead of the subject vehicle. The detection can be made with the use of V2V signals sent from the communicating vehicle. The signals may include data on the position of the communicating vehicle. Detecting S1 the communicating vehicle may comprise detecting a vehicle in front of the subject vehicle. Detecting the vehicle in front of the subject vehicle may be done by means of one or more sensors of the subject vehicle. The vehicle in front of the subject vehicle may potentially be the communicating vehicle. The detection of the communicating vehicle by means of the V2V signals, and the detection of the vehicle in front of the subject vehicle, may be done substantially at the same time.

[0047] The method further comprises the subject vehicle 1 determining S2, by means of a length determination procedure, an assumed length Las of the communicating vehicle 2. The length determination procedure comprises determining a rear portion distance Drp (fig. 1, fig. 2), as a distance between the subject vehicle and a rear portion of a vehicle in front of the subject vehicle. The rear portion distance Drp is determined by means of one or more sensors of the subject vehicle, for example the radar sensor 111.

[0048] The length determination procedure further comprises determining a front portion distance Dfp. The front portion distance is a distance between the subject vehicle 1 and a front portion of the communicating vehicle 2. For example, the front portion distance may be a distance between a front portion of subject vehicle and the front portion of the communicating vehicle.

[0049] The position of the subject vehicle may be provided by a positioning device in the subject vehicle. The positioning device may be adapted to use the Global Navigation Satellite System (GNSS). The control unit 102 of the subject vehicle may be arranged to receive data on the position of the subject vehicle from the positioning device.

[0050] The position of the front portion of the communicating vehicle may be sent from the communicating vehicle 2 to the subject vehicle 1 with the V2V communication. The position of the front portion of the communicating vehicle may be provided by a positioning device in the communicating vehicle, e.g. adapted to use the GNSS.

[0051] The assumed length Las of the communicating vehicle 2 may be determined in dependence on the rear portion distance Drp and the front portion distance Dfp. For example, the assumed length Las of the communicating vehicle 2 may be determined as a difference between the front portion distance Dfp and the rear portion distance Drp.

[0052] The method may comprise determining S3 whether length information about the length L1 of the communicating vehicle is available to the subject vehicle. Here, the length information is regarded as information obtained in a way that is different from the way that the assumed length is determined.

[0053] The length information may be received by the subject vehicle 1 from the communicating vehicle 2 by means of the V2V communication. Alternatively, the length information may be obtained by the subject vehicle retrieving the length information from a database. The database may be located remotely from the subject vehicle, as indicated with item 401 in fig. 1 and fig. 2. Alternatively, the database may be provided in the subject vehicle. In the former case, the length information may be received by the subject vehicle, e.g. wirelessly, upon the subject vehicle sending a request to the database 401, together with information identifying the communicating vehicle.

[0054] The method comprises, if length information about the length L1 of the communicating vehicle is available S3 to the subject vehicle, the subject vehicle comparing S4 the assumed length Las with the length according to the length information.

[0055] If the assumed length Las differs from the length L1 according to the length information by less than a difference threshold value, the subject vehicle connects S5 to the communicating vehicle. Thereby, the second vehicle will form a part of a platooning process with the communicating vehicle. It should be noted that a platooning process may, or may not, include further vehicles, e.g. in front of the communicating vehicle.

[0056] If the assumed length Las differs from the length L1 according to the length information by more than the difference threshold value, the subject vehicle 1 performs S6 a target identification procedure, described below. The difference between the assumed length Las and the length L1 according to the length information may be due to another vehicle being present between the subject vehicle 1 and the communicating vehicle 2, as exemplified in fig. 2. The difference between the assumed length Las and the length L1 according to the length information may alternatively be due to the length information not being updated after a change of the length of the communicating vehicle 2. Such a change may occur for example, if a trailer, pulled by a tractor of the communicating vehicle, is changed to another trailer with a different length.

[0057] The target identification procedure S6 is executed to determine whether the vehicle in front of the subject vehicle 1 is the communicating vehicle 2. The target identification procedure may comprise the subject vehicle requesting with the V2V communication the that the communicating vehicle performs an action. The action may be for example the communicating vehicle activating a turn signal. The action may be detected by the subject vehicle, e.g. by means of a camera of the subject vehicle. The subject vehicle determines S7, in dependence on detecting a response to the request, whether the vehicle in front of the subject vehicle 1 is the communicating vehicle 2. The subject vehicle may determine that the vehicle in front is the communicating vehicle if the subject vehicle detects that the vehicle in front performs the action.

[0058] If it is determined by the performed target identification procedure that the vehicle in front of the subject vehicle is the communicating vehicle, the subject vehicle connects S8 to the communicating vehicle. Further, if S7 it is determined by the performed target identification procedure that the vehicle in front of the subject vehicle is the communicating vehicle, the subject vehicle sends a request to store S10 the assumed length Las in the database 401. Thereby, obsolete information of the length of the communicating vehicle may be updated. Thereby, future platoon connection procedures may be facilitated. In some embodiments, the subject vehicle may store S10 the assumed length Las in a database in the subject vehicle.

[0059] As exemplified above, the method advantageously comprises registering a time and position at which the assumed length was determined. Thereby, storing S10 the assumed length in the database comprises storing in the database the time and position at which the assumed length was determined.

[0060] If it is determined by the performed target identification procedure that the vehicle in front of the subject vehicle is not the communicating vehicle, the subject vehicle determines S9 to not connect to the communicating vehicle.

[0061] If it is determined S3 that the length information is not available to the subject vehicle, the subject vehicle 1 performs S6 the target identification procedure exemplified above. Again, if it is determined S7 by the performed target identification procedure that the vehicle in front of the subject vehicle is the communicating vehicle 2, the subject vehicle connects S8 to the communicating vehicle. Also, if it is determined S7 by the performed target identification procedure that the vehicle in front of the subject vehicle is the communicating vehicle, the subject vehicle sends a request to store S10 the assumed length Las in the database 401. Again, in some embodiments, the subject vehicle may store S10 the assumed length Las in a database in the subject vehicle. Again, if it is determined S7 by the performed target identification procedure that the vehicle in front of the subject vehicle is not the communicating vehicle, the subject vehicle determines S9 to not connect to the communicating vehicle.

[0062] Fig. 4 depicts steps in a method according to a more general embodiment of the invention. The method may involve vehicles as in the embodiments described above. The method comprises a subject vehicle determining S2, by means of a length determination procedure, an assumed length Las of a communicating vehicle travelling ahead of the subject vehicle. If length information about the length L1 of the communicating vehicle is available S3 to the subject vehicle, the length information being obtained in a way that is different from said length determination procedure, the subject vehicle compares S4 the assumed length with the length according to the length information, and connects S5 to the communicating vehicle if the assumed length Las differs from the length L1 according to the length information by less than a difference threshold value.

[0063] It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims.

Claims

1. A method for Cooperative Adaptive Cruise Control (CACC) with vehicle-to-vehicle (V2V) communication, the method comprising

    - a subject vehicle determining (S2), by means of a length determination procedure, an assumed length (Las) of a communicating vehicle travelling ahead of the subject vehicle,
    - **characterized by**, if length information about the length (L1) of the communicating vehicle is available (S3) to the subject vehicle, the length information being obtained in a way that is different from said length determination procedure, the subject vehicle comparing (S4) the assumed length with the length according to the length information, and connecting (S5) to the communicating vehicle if the assumed length (Las) differs from the length (L1) according to the length information by less than a difference threshold value.

2. A method according to claim 1, **characterized in that** the length information is obtained by retrieving the length information from a database.

3. A method according to any one of the preceding claims, **characterized in that** the length information is obtained by receiving the length information from the communicating vehicle by the V2V communication.

4. A method according to any one of the preceding claims, **characterized in that** the length determination procedure comprises determining a rear portion distance (Drp), the rear portion distance being a distance between the subject vehicle and a rear portion of a vehicle in front of the subject vehicle, determining a front portion distance (Dfp), the front portion distance being a distance between the subject vehicle and a front portion of the communicating vehicle, and determining the assumed length (Las) in dependence on the rear portion distance and the front portion distance.

5. A method according to 4, **characterized in that** the rear portion distance (Drp) is determined by means of one or more sensors of the subject vehicle.

6. A method according to any one of claims 4-5, **characterized in that** the position of the front portion of the communicating vehicle is sent from the communicating vehicle with the V2V communication.

7. A method according to any one of the preceding claims, **characterized by**, if (S4) the assumed length (Las) differs from the length (L1) according to the length information by more than the difference threshold value, performing (S6) a target identification procedure to determine whether the vehicle in front of the subject vehicle is the communicating vehicle.

8. A method according to any one of the preceding claims, **characterized by**, if (S3) the length information is not available to the subject vehicle, performing (S6) a target identification procedure to determine whether the vehicle in front of the subject vehicle is the communicating vehicle.

9. A method according to any one of claims 7-8, **characterized in that** the target identification procedure comprises the subject vehicle requesting with the V2V communication the that the communicating vehicle performs an action, and determining that the vehicle in front is the communicating vehicle if the subject vehicle detects that the vehicle in front per-

forms the action.

10. A method according to any one of claims 7-9, **characterized by**, if (S7) it is determined by the performed target identification procedure that the vehicle in front of the subject vehicle is not the communicating vehicle, the subject vehicle determining (S9) to not connect to the communicating vehicle.

11. A method according to any one of claims 7-10, **characterized by**, if (S7) it is determined by the performed target identification procedure that the vehicle in front of the subject vehicle is the communicating vehicle, the subject vehicle connecting (S8) to the communicating vehicle.

12. A method according to any one of claims 7-11, **characterized by**, if (S7) it is determined by the performed target identification procedure that the vehicle in front of the subject vehicle is the communicating vehicle, the assumed length (Las) being stored (S10) in a database.

13. A method according to claim 12, **characterized by** registering a time at which the assumed length was determined by means of the length determination procedure, wherein storing (S10) the assumed length in the database comprises storing in the database the time at which the assumed length was determined.

14. A method for Cooperative Adaptive Cruise Control (CACC) with vehicle-to-vehicle (V2V) communication, the method comprising

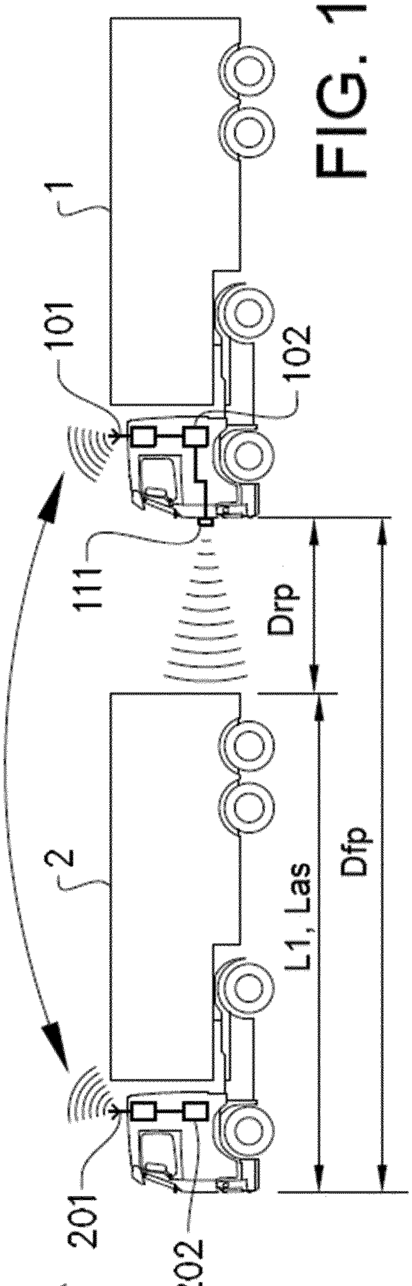
- determining a rear portion distance (Drp), the rear portion distance being a distance between a subject vehicle and a rear portion of a vehicle in front of the subject vehicle, determining a front portion distance (Dfp), the front portion distance being a distance between the subject vehicle and a front portion of a communicating vehicle travelling ahead of the subject vehicle, and determining (S2) an assumed length (Las) of the communicating vehicle in dependence on the rear portion distance and the front portion distance,
- **characterized by** the subject vehicle requesting (S6), with the V2V communication, that the communicating vehicle performs an action, and
- the subject vehicle connecting (S8) to the communicating vehicle if the subject vehicle detects that the vehicle in front performs the action.

15. A computer program comprising program code means for performing the steps of any one of the preceding claims when said program is run on a computer.

16. A computer readable medium carrying a computer program comprising program code means for performing the steps of any one of claims 1-14 when said program product is run on a computer.

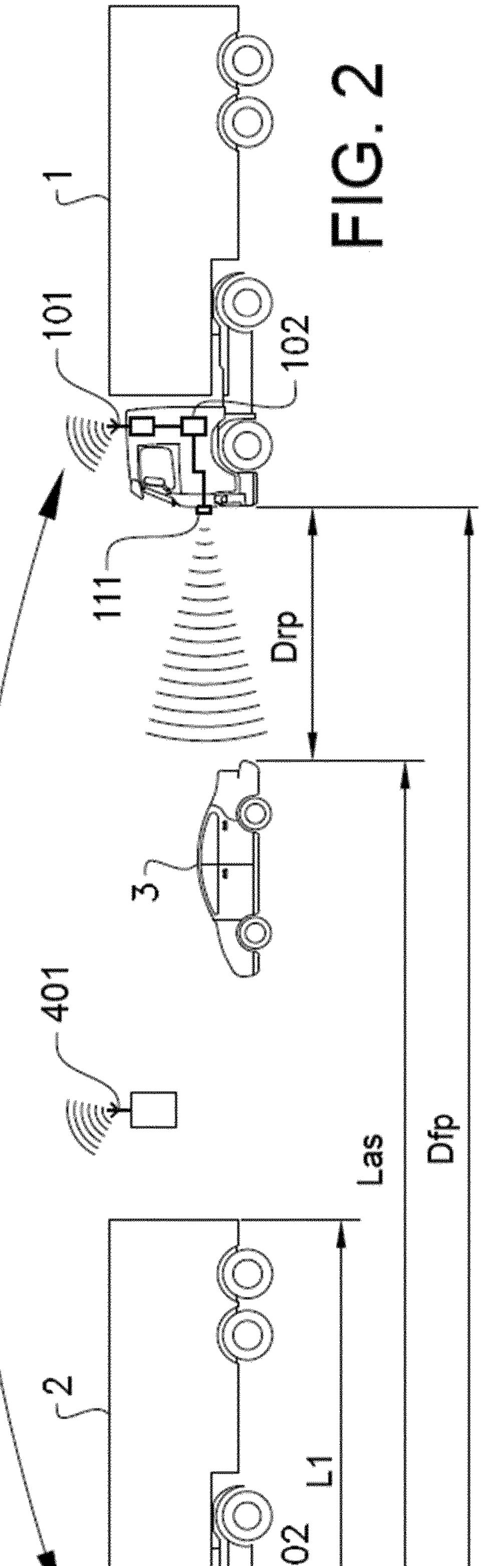
17. A control unit, or a group of control units, configured to perform the steps of the method according to any one of claims 1-14.

18. A vehicle comprising a control unit according to claim 17.



1
101
102
111
Drp
Dfp
2
L1, Las
201
202
401

FIG. 1



1
101
102
111
Drp
3
401
Las
Dfp
2
L1
201
202

FIG. 2

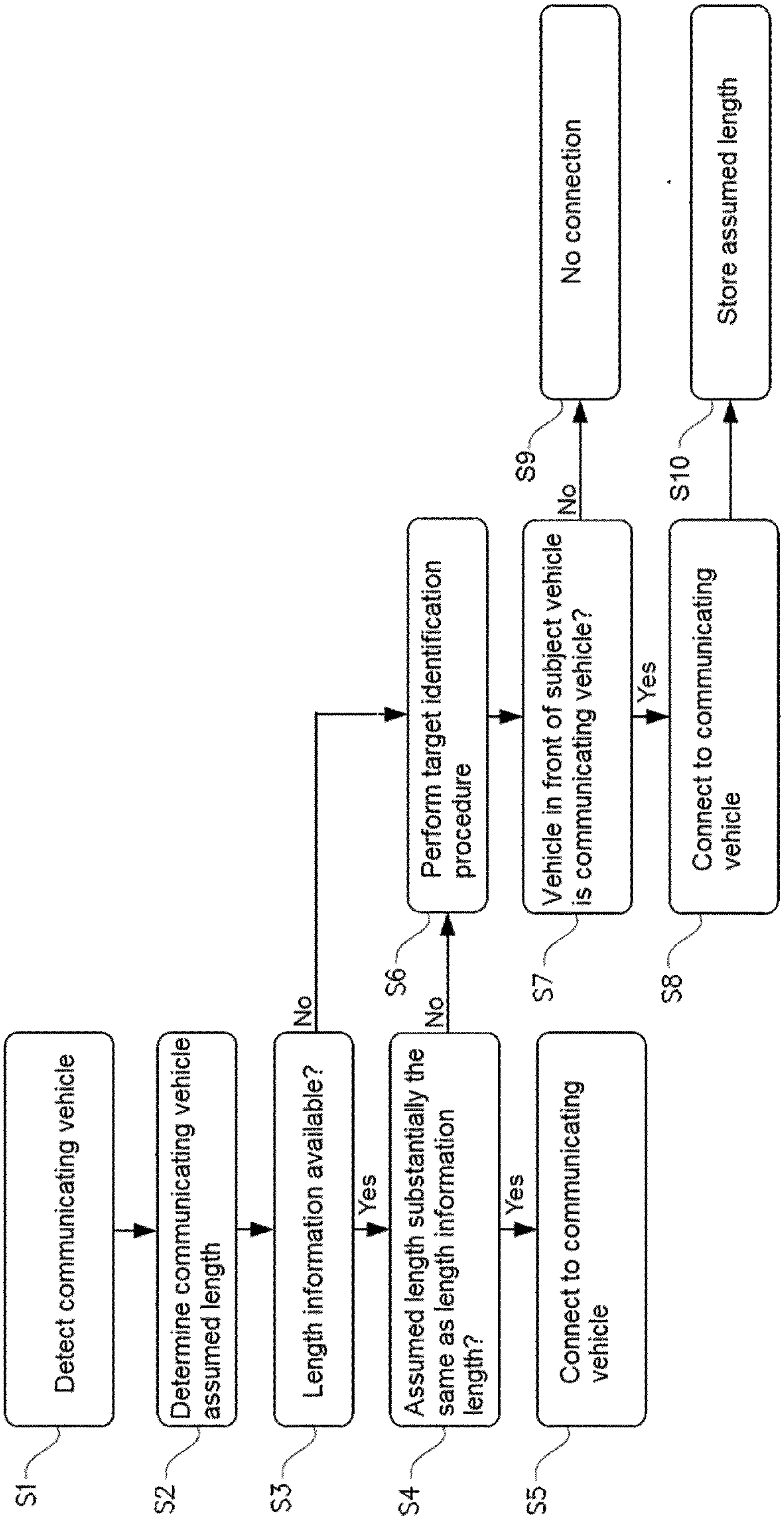

S1
Detect communicating vehicle
S2
Determine communicating vehicle assumed length
S3
Length information available?
Yes
No
S4
Assumed length substantially the same as length information length?
Yes
No
S5
Connect to communicating vehicle
S6
Perform target identification procedure
S7
Vehicle in front of subject vehicle is communicating vehicle?
Yes
No
S8
Connect to communicating vehicle
S9
No connection
S10
Store assumed length

FIG. 3

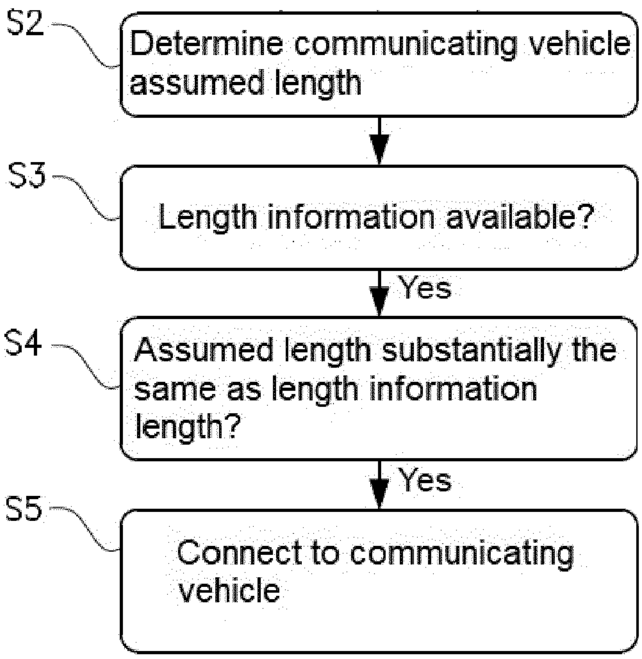

S2
Determine communicating vehicle assumed length
S3
Length information available?
Yes
S4
Assumed length substantially the same as length information length?
Yes
S5
Connect to communicating vehicle

FIG. 4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 20 9394

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D A	WO 2013/187834 A1 (SCANIA CV AB [SE]) 19 December 2013 (2013-12-19) * page 5, line 7 - page 12, line 25 *	1,2,6 3-5,7-18	INV. G08G1/00
X Y	CA 3 004 051 A1 (PELOTON TECH INC [US]) 27 April 2017 (2017-04-27) * paragraphs [0083], [0131]; figures 11a, 18 *	1,3, 7-13,18 4,5,14	
Y	US 2012/188374 A1 (TANER ANIL [DE]) 26 July 2012 (2012-07-26) * paragraph [0011] *	4,5,14	
A	EP 2 843 645 A1 (TOYOTA MOTOR CO LTD [JP]) 4 March 2015 (2015-03-04) * paragraph [0003] *	3	

TECHNICAL FIELDS SEARCHED (IPC)

G08G

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	7 May 2021	Pinto, Raúl

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 20 9394

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

07-05-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2013187834 A1	19-12-2013	EP 2862158 A1	22-04-2015
		SE 1250629 A1	15-12-2013
		WO 2013187834 A1	19-12-2013
CA 3004051 A1	27-04-2017	CA 3004051 A1	27-04-2017
		EP 3353615 A1	01-08-2018
		WO 2017070714 A1	27-04-2017
US 2012188374 A1	26-07-2012	CN 102610125 A	25-07-2012
		DE 102011009106 A1	26-07-2012
		EP 2479077 A1	25-07-2012
		US 2012188374 A1	26-07-2012
EP 2843645 A1	04-03-2015	CN 104246851 A	24-12-2014
		EP 2843645 A1	04-03-2015
		JP 5522193 B2	18-06-2014
		JP 2013228804 A	07-11-2013
		US 2015178247 A1	25-06-2015
		WO 2013161467 A1	31-10-2013

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- WO 13187834 A **[0005]**