(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 April 2007 (19.04.2007)

PCT

(10) International Publication Number
WO 2007/042860 A1

(51) International Patent Classification:
B62D 7/09 (2006.01) *B62D 9/00* (2006.01)

(21) International Application Number: PCT/IB2005/003646

(22) International Filing Date: 11 October 2005 (11.10.2005)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant (*for all designated States except US*): **RENAULT TRUCKS** [FR/FR]; 99, route de Lyon, F-69800 Saint Priest (FR).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): **DECHAMP, François** [FR/FR]; Lotissement des Grandes Terres, F-71250 CLUNY (FR).

(74) Agent: **CABINET, GERMAIN, &, MAUREAU**; BP 6153, Cedex 06, F-69466 Lyon (FR).

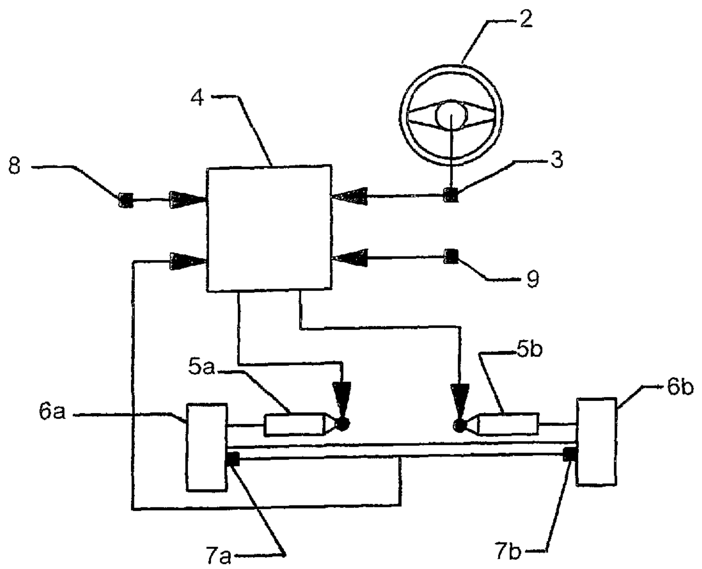
(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD FOR CONTROLLING A STEER-BY-WIRE STEERING SYSTEM



(57) Abstract: The method is aimed at controlling a steer-by-wire steering system of a vehicle having at least one steering axle having at least two steer wheels (6a, 6b) electronically controlled by a control member. In the case of asymmetric adhesion conditions, the method anticipates steering into the skid for the first steer wheel (6a) that is on the surface exhibiting the higher coefficient of adhesion - for example asphalt - so as to counter a moment applied to the Z-axis; At the same time, the second steer wheel (6b) which is on the surface having the lower coefficient of adhesion - for example a sheet of black ice - remains in the vehicle direction of travel or is oriented towards the second steer wheel (6a) in a snow plough mode. The vehicle stability is vastly improved when the vehicle regains an area of uniform adhesion.

WO 2007/042860 A1

Method for controlling a steer-by-wire steering system

Technical field

The present invention relates to a method for controlling a steer-by-wire steering system.

Background of the invention

Traditionally, in a land vehicle, the steering, that is to say all of the means that are used to direct the course followed by the vehicle, is produced using a mechanism which connects a control member, generally a steering wheel, to at least one steering axle generally comprising two steer wheels and which makes it possible to alter the orientation of the wheels with respect to the vehicle. The mechanism may be power-assisted by electrical or hydraulic means in order to facilitate the transmission of the force used to turn the control member up to each wheel of the steering axle.

There is also another type of steering system known as steer-by-wire steering in which the control member is mechanically decoupled from the steering axle.

Schematically speaking, a steer-by-wire steering system comprises a control member (steering wheel, hand tiller, joystick) on which a driver can act. By acting on the control member, the driver sets a direction to be given to the vehicle; the movement that the driver applies to the control member is identified by a position sensor (an angle sensor in the case where the control member is a steer wheel); the signal originating from the position sensor that senses the position of the control member is processed appropriately, then transmitted to one or more actuators which can act on the orientation of the wheels with respect to the vehicle, according to the action that the driver has exerted on the control member. It may be emphasized that a resistive torque is applied to the control member so that the driver has a feeling that reproduces the force exerted by the wheel on a running surface. This resistive torque may be a function of numerous factors; these may, for example, include the speed or acceleration of the vehicle, the speed or acceleration of the action exerted by the driver on the control member.

This type of steering has numerous advantages over conventional steering systems. This type of steering in particular reduces the risk of injury by contact with the steering column in the event of an accident and can be readily parameterized. It is also particularly advantageous in the case of industrial vehicles, of the truck type, which are bound by tight architectural constraints and generally have a cabin decoupled from the chassis. A steer-by-wire steering system in particular avoids having to resort to a conventional steering column, which has to be rigidly fixed both to the cabin and to the chassis.

Thanks to the electronic control exerted on the wheel orientation actuator or actuators, it becomes possible to use the steering as an element to make the running of a vehicle safer. It is thus possible, under particular driving circumstances, to give the steer wheels an orientation that may make it possible to maintain the stability of the vehicle and thus avoid a loss of control of the vehicle that could possibly lead to an accident.

One driving circumstance that potentially leads to accidents may be braking on an area where the adhesion is asymmetric; that is to say on an area that exhibits different coefficients of adhesion.

Typically, this type of circumstance is encountered when a vehicle is running along a road, which has a sheet of black ice or a puddle. In such a scenario, one wheel of the steering axle may find itself on a surface that exhibits good adhesion while the second wheel of the steering axle may find itself on a surface of low adhesion; insofar as these two wheels are subjected to the same braking action, the vehicle may then pivot, with respect to the wheel which is in contact with the surface of higher adhesion, and this may cause sideslip as the rear axle steps out. This is commonly known as "swapping ends" when the vehicle pivots through 180°. In other words, the yaw Rz, that is to say the moment of the force applied to the Z-axis of the vehicle, exceeds a value that the vehicle can withstand and the vehicle no longer follows the course set for it by the driver.

To combat this type of incident it is known, for example, in the case of a vehicle equipped with an antilock braking system (ABS), to regulate the braking power at the wheel in contact with the running surface having the lower coefficient of adhesion to prevent this wheel from locking up. That nonetheless has the negative consequence of an overall loss in braking power and a lengthening of the vehicle stopping distance because the braking system uses, as its reference, the wheel that is in contact with the surface of lower adhesion.

Another measure that makes it possible to combat sideslip in the case of braking on a surface that has asymmetric adhesion is to steer into the skid; this measure is aimed at orienting the steer wheels in the opposite direction to the direction of sideslip. In the case of steer-by-wire steering, it is possible in a sideslip situation to act on the steering actuator or actuators in order to steer into the skid even before the driver has reacted to the sideslip situation. It may be recalled on this subject that the reaction time of a driver is 0.7 second at best, whereas a steer-by-wire steering system can act on the wheels in a far shorter space of time.

A problem may nonetheless arise when the vehicle, the steer wheels of which have had opposite lock applied to them, leaves the area of asymmetric adhesion. What happens then is that the vehicle is in a condition in which its steer wheels are not along the axis of the vehicle although the conditions of adhesion are such that the two wheels are in contact with a surface exhibiting a uniform coefficient of adhesion.

Thus, it appears that the way of managing a vehicle that has to brake on a surface exhibiting asymmetric adhesion is not entirely satisfactory.

Summary of the invention

One object of the invention is to propose a method for controlling a steer-by-wire steering system that makes it possible to stabilize the path of a vehicle during a transition from an area of asymmetric adhesion to an area of uniform adhesion.

Another object of the invention is to propose a method for controlling a steer-by-wire steering system that makes it possible to stabilize the path of a vehicle in the braking phase during a transition from an area of asymmetric adhesion to an area of uniform adhesion.

The subject of the invention is essentially a method for controlling a steer-by-wire steering system of a vehicle having at least one steering axle having at least two steer wheels controlled by a control member. The method can comprise the steps of: detecting a difference in behaviour between a first steer wheel and a second steer wheel thereby indicating asymmetric steer wheel adhesion, the first steer wheel being in contact with a first area which exhibits a first coefficient of adhesion and the second steer wheel being in contact with a second area which exhibits a second coefficient of adhesion, the first coefficient of adhesion being higher than the second coefficient of adhesion; calculating a theoretical yaw parameter as a function at least of the actual speed of the vehicle and of the actual position of the control member; measuring the actual yaw parameter using a yaw sensor; comparing the actual yaw parameter with the theoretical yaw parameter; angling the wheel in contact with the area exhibiting the first coefficient of adhesion by an angle θ1, whereby the first steer wheel is oriented in a direction opposing the yaw, and angling the wheel in contact with the area exhibiting the second coefficient of adhesion by an angle θ2, with θ2 being comprised between a value whereby the second steer wheel is oriented substantially in the vehicle direction of travel and a value whereby the second steer wheel is oriented towards the first steer wheel, if the difference between the actual yaw parameter and the theoretical yaw exceeds a reference data.

The method according to the invention has the notable effect of not maintaining the near-parallel configuration of the steer wheels when these are steered into the skid in order to combat a yaw Rz applied about the Z-axis of the vehicle. In the case of asymmetric adhesion conditions, the method anticipates steering into the skid for the first steer wheel that is on the surface exhibiting the higher coefficient of adhesion - for example asphalt - so as to counter a moment applied to the Z-axis. At the same time, the second steer wheel which is on the surface having the lower coefficient of adhesion - for example a sheet of black ice or a puddle - remains in the vehicle direction of travel or is oriented towards the second steer wheel. In the latter scenario, the steer wheels are oriented in opposite and converging directions and adopt a "snowplough" position. Thus, when the vehicle leaves an area of asymmetric adhesion to regain an area of uniform adhesion, the behaviour of the vehicle is far more stable than when the vehicle regains an area of uniform adhesion with its two steer wheels in a position of steering into the skid. It may be noted that the fact of not steering into the skid, for the steer wheel that is in contact with the surface having the lower coefficient of adhesion, has no major impact on the action aimed at countering the yaw Rz. The action aimed at countering the yaw Rz is essentially due to the steer wheel that is in contact with the surface having the higher coefficient of adhesion; the action of the wheel in contact with the surface having the lower coefficient of adhesion is in any event limited.

In a possible embodiment, the method according to the invention can be implemented for controlling a steering system of a vehicle having at least one steering axle having at least two steer wheels; the steer-by-wire-type steering system can comprise, in particular: at least one sensor making it possible to identify the position of a control member; two actuators able to act respectively on each of the steer wheels in order to orient them independently by an angle θ1 and θ2 with respect to the longitudinal axis of the vehicle; a CPU able to receive an input signal originating from the sensor and able to emit an output signal bound for each of the actuators.

The method for controlling this steering system comprises the steps of: detecting a difference in behaviour between a first steer wheel and a second steer wheel thereby indicating asymmetric steer wheel adhesion, the first steer wheel being in contact with a first area which exhibits a first coefficient of adhesion and the second steer wheel being in contact with a second area which exhibits a second coefficient of adhesion, the first coefficient of adhesion being higher than the second coefficient of adhesion; calculating a theoretical yaw parameter as a function at least of the actual speed of the vehicle and of the actual position of the control member; measuring the actual yaw parameter using a yaw sensor; comparing the actual yaw parameter with the set-point yaw parameter; acting on the actuator of the first steer wheel in contact with the area exhibiting the first coefficient of adhesion in order to angle the steer wheel by an angle θ1 such that the first steer wheel is oriented in a direction opposing the yaw; and acting on the actuator of the second steer wheel in contact with the area exhibiting the second coefficient of adhesion in order to angle the wheel by an angle θ2, with θ2 being comprised between a value whereby the second steer wheel is oriented substantially in the vehicle direction of travel and a value whereby the second steer wheel is oriented towards the first steer wheel, if the difference between the actual yaw parameter and the theoretical yaw exceeds a reference data.

According to a favourite form of the invention, the step of detecting the difference in adhesion between the two steer wheels is performed while the vehicle is under braking, because it is under braking that the vehicle is most likely to escape the control of its driver.

In one implementation of the method according to the invention, the angle θ2 formed by the steer wheel in contact with the surface having the lower coefficient of adhesion and the longitudinal axis of the vehicle can be nil. This scenario can be especially advantageous when the vehicle runs on a straight line and brakes on an asymmetrical adhesion surface. The steer wheel which is in contact with the area having a high coefficient of adhesion is angled so as to combat the yaw but the steer wheel, which is in contact with an area exhibiting a low coefficient of adhesion, can remain in the longitudinal axis of the vehicle. This may be advantageous when the braking set-point is not very high, that is to say when the driver merely wishes to slow his vehicle down.

In another implementation of the invention, the angle θ2 formed by the steer wheel in contact with the surface having the lower coefficient of adhesion and the longitudinal axis of the vehicle is oriented in a direction equal to the direction of the yaw speed and is greater than zero. The vehicle is then in a configuration in which its steer wheels form a "snowplough" and this enhances the effectiveness of the braking while at the same time keeping the vehicle in a straight line when the vehicle regains conditions of uniform adhesion. This might be advantageous if the vehicle driver wants to bring his vehicle to a complete stop.

It can be preferentially anticipated for the angle θ1 formed by the steer wheel in contact with the surface having the higher coefficient of adhesion and the longitudinal axis of the vehicle and for the angle θ2 formed by the steer wheel in contact with the surface having the lower coefficient of adhesion and the longitudinal axis of the vehicle to be oriented in opposite directions and to have the same magnitude. This makes it possible to maintain symmetry in the orientation of the wheels and this is beneficial to the stability of the vehicle in the transition between an area of asymmetric adhesion and an area of symmetric adhesion.

In the case of a vehicle running along a curve, the steer wheels of the vehicle are respectively angled by $\theta 1i$ and $\theta 2i$; $\theta 1i$ and $\theta 2i$ are substantially equal and are a function of the radius of the curve. Should a vehicle encounter asymmetrical adhesion conditions, the method may comprise the step of modifying the initial angles $\theta 1i$ and $\theta 2i$ formed respectively by the steer wheels with the longitudinal axis of the vehicle by respectively $\theta 1$ and $\theta 2$.

In one practical embodiment of the method according to the invention, the step of detecting a difference in behaviour thereby indicating asymmetric steer wheel adhesion, one wheel being in contact with an area having a first coefficient of adhesion and one wheel being in contact with a surface of low adhesion, is performed using the speed sensors of each of the steer wheels of an antilock braking (ABS) system.

These and other advantages will become apparent upon reading the following description in view of the drawing attached hereto representing, as a non-limiting example, an embodiment of a seat according to the invention.

Brief description of the figures

The following detailed description of embodiments of the invention is better understood when read in conjunction with the appended drawing being understood, however, that the invention is not limited to the specific embodiments disclosed. In the drawing,

Figure 1 shows a vehicle with the forces and moments exerted on said vehicle.

Figure 2 is a block diagram of a steer-by-wire steering system employing one embodiment of the method according to the invention,

Figure 3 is a simplified diagram illustrating one possible method of formulating signals applied to actuators responsible for orienting the steer wheels,

Figure 4 schematically shows a known way of combating a loss of control of a vehicle on an area of asymmetric adhesion,

Figure 5 schematically shows one possible way according to the method of the invention of combating a loss of control of a vehicle in an area of asymmetric adhesion,

Figure 6 schematically shows another possible way according to the method of the invention of combating a loss of control of a vehicle in an area of asymmetric adhesion.

Description of the invention

First of all, let us remember that a vehicle which is moving along is subjected to the action of three forces which are: the drag Fx, the sideslip Fy, and the lift Fz. The moments of these forces are determined with respect to a frame of reference centred on the centre of gravity of the vehicle and having three orthogonal axes X – longitudinal -, Y – transverse -, Z – vertical -. As represented in figure 1, these moments are:

- roll Rx, in the case of drag,
- pitch Ry, in the case of sideslip,
- yaw Rz, in the case of lift.

The stability of the vehicle is inversely proportional to the moments of these forces; in other words, the better these forces are minimized, the more stable a vehicle is.

Referring first of all to figure 2, it is possible to see that the steer-by-wire steering system can comprise a control member 2 which, in the case illustrated, is a steer wheel. The control member 2 could be a hand tiller, a lever or a rudder bar. It is by virtue of this member that the driver sets a set-point path to be given to the vehicle.

The angle that a driver applies to the control member 2 is measured by a sensor 3, the signal of which is transmitted to a CPU 4. The

CPU 4 can suitably include a microprocessor, a data memory such as a RAM memory and a program memory such as a ROM memory.

According to a preloaded calculation routine, the CPU 4 generates an output signal, which can be transmitted to two actuators 5a, 5b responsible, respectively, for orienting two steer wheels 6a, 6b with respect to the longitudinal axis of the vehicle.

In the example depicted, it may also be noted that each of the steer wheels 6a, 6b can be equipped with an antilock braking system (ABS system) comprising, in a known way, wheel speed sensors 7a, 7b which can be connected to a CPU (not depicted in the drawing). This CPU is able to limit the extent to which the wheels lock up under braking on a surface that offers very little adhesion.

To implement the method according to the invention the vehicle can also be equipped with a yaw sensor 8. The yaw sensor 8 measures the yaw speed, that is to say the rotational speed of the chassis about its vertical axis. The yaw sensor 8 can be situated at the centre of the vehicle near the centre of gravity or, if it is positioned at a location offset from the centre, an electronic program repositions it in a virtual sense at the centre of gravity.

The data measured by the yaw sensor 8 can be used in an electronic stability system (ESP) preventing sideslip for controlling the path followed, and which does not form part of the present invention.

In the method according to the invention, the data measured by the yaw sensor 8 can be compared with a theoretical yaw speed. The theoretical yaw speed can be determined as a function of the angle that the driver has given to the control member 2 and the speed of the vehicle. Other parameters may be taken into consideration in determining the theoretical yaw speed such as the load of the vehicle.

As has been seen, the object of the invention is to improve the stability of a vehicle when it is running along a surface with asymmetric adhesion. This type of condition may be encountered, for example, when the vehicle is running along a road surface partially covered in black ice. In this case, one steer wheel 6a may find itself on an area exhibiting low adhesion – for example, black ice - while the other steer wheel 6b finds itself on an area exhibiting good adhesion – for example, dry tarmac -; this type of condition is extremely commonplace particularly in the winter period and may cause accidents through the driver losing control of his vehicle. In figures 4 to 6, the area of low adhesion is symbolically bounded by dotted lines.

In such a scenario, if the driver commands his vehicle to brake, the braking is unbalanced because the steer wheels 6a, 6b are in contact with a surface that has different coefficients of adhesion.

This imbalance can be picked up by the wheel speed sensors 7a, 7b of the ABS braking system.

A signal originating from the ABS speed sensors 7a, 7b can be carried to the CPU 4 indicating a difference between the speeds of the steer wheels 6a, 6b, and this testifies to asymmetry in the conditions of adhesion between the two steer wheels; this is represented by the block 100 in figure 2.

The consequence of this imbalance is that the vehicle may go into oversteer, that is to say may experience sideslip as its back end steps out.

In the form illustrated, in the step 200 the CPU 4 can receive a signal originating from the sensor 3 connected to the control member 2 indicating the position thereof, and a signal originating from a speed sensor 9 indicating the speed of the vehicle. Using these two signals, the computer can formulate a theoretical yaw speed.

At the same time, in the step 300, the CPU 4 can receive from the yaw sensor 8 the actual yaw speed that the vehicle is experiencing.

In the current situation, that is to say under braking in an area of asymmetric adhesion leading to oversteer, the actual yaw speed is different from the theoretical yaw speed, and is greater than the latter.

In concrete terms, this is manifested in the fact that the vehicle can escape the control of its driver that is to say that the vehicle no longer follows the set-point path that the driver wishes to give to his vehicle. This thus results in a loss of control of the vehicle.

If the difference between the actual yaw parameter and the theorical yaw parameter exceeds a reference data - threshold value or a function of the difference such as a variation rate of the difference -, the CPU 4 then formulates a set-point angle θ1 and θ2 to be applied to each of the steer wheels 6a,6b of the vehicle in order to combat the oversteer, and this is represented by block 400 in figure 3.

Figure 4 illustrates a conventional way of combating oversteer, that is to say of opposing the yaw moment Rz. This conventional method is to orient each of the steer wheels 6a, 6b by an angle θ. The important point to note is that the two steer wheels 6a, 6b are oriented by substantially the same angle in the opposite direction to the direction in which the moment is applied to the vehicle.

The problem is then that the vehicle, which continues its journey, regains conditions of uniform adhesion. Now, given that the actuators 5a, 5b cannot instantaneously re-orient the wheels 6a, 6b along the axis of the vehicle when the vehicle regains conditions of uniform adhesion, the stability of the vehicle is greatly disrupted.

In order to remedy that, in the method according to the invention, the CPU 4 formulates a set-point angle θ1 for the wheel 7a which is on the surface of greater adhesion. The angle θ1 is oriented in the direction opposite to the direction of the moment Rz to combat the oversteering of the vehicle.

By contrast, the CPU 4 formulates a set-point angle θ2 for the wheel 6b which is on the surface of lower adhesion. The set-point angle θ2 is different from the set-point angle θ1; the near-parallel configuration normally found between two steer wheels is not maintained.

It is, for example, possible to anticipate two scenarios as far as the orientation of the steer wheels 6a, 6b is concerned.

One scenario which is illustrated in figure 5 is to formulate a set-point angle θ2 that is not nil but oriented in the same direction as the moment Rz applied to the vehicle as a result of the asymmetric adhesion conditions. What this amounts to is placing the two wheels 6a, 6b in a configuration in which the steer wheels 6a,6b converge and thus adopt a configuration that could be called a snowplough configuration. This first scenario may be encouraged when the braking set-point is high - for example, when the driver wishes to bring his vehicle to rest -; this is because the vehicle is then in a configuration in which its steer wheels are in a snowplough configuration, which enhances the effectiveness of the braking action while at the same time keeping the vehicle in a straight line when the vehicle regains conditions of uniform adhesion. It is preferable for the angles θ1 and θ2, which are oriented in opposite directions, to have the same magnitude in order to preserve the equilibrium of the vehicle when it regains conditions of uniform adhesion. The transition between the area of asymmetric adhesion and the area of uniform adhesion therefore takes place with markedly less disruption than in the case of steer wheels oriented as shown in figure 3.

Another scenario which is illustrated by figure 5 may anticipate formulating a zero set-point angle θ1; the steer wheel 6b then remains along the axis of the vehicle. This other scenario may be encouraged when the braking set-point is not very high – for example when the driver merely wishes to slow his vehicle down - ; what actually happens is that one of the wheels - the wheel in contact with the surface of lower coefficient of adhesion - is along the axis of the vehicle, and is thus in position for the vehicle to continue along its path.

It may also be anticipated for the orientation of the wheel 6b to be varied between a position in which θ2 is nil and a position in which θ2 is not nil as a function of a driving parameter such as, for example, a variation in the braking set-point given by the driver.

It must be appreciated that although the method according to the invention has been described in relation to a vehicle braking on asymmetrical adhesion condition and running in a straight line, the method can of course be implemented in a vehicle braking on asymmetrical adhesion condition and running in a curve. In this latter case, the wheel 6a, 6b can already be angled by initial angles $\theta 1i$ and $\theta 2i$ - $\theta 1i$ and $\theta 2i$ depend on the radius of the curve - when the vehicle reaches an area of on asymmetrical adhesion. The initial orientations $\theta 1i$ and $\theta 2i$ of the wheels 6a, 6b are modified respectively by $\theta 1$ and $\theta 2$, $\theta 1$ and $\theta 2$ being formulated in the same way as they are previously in the case of a vehicle running in a straight line.

Of course, the invention is not limited to the embodiment just described but on the contrary encompasses all embodiments thereof.

CLAIMS

1. A method for controlling a steer-by-wire steering system of a vehicle having at least one steering axle having at least two steer wheels (6a, 6b) each controlled by a control member (5a,5b), characterized in that the method comprises the steps of:

- detecting (100) a difference in behaviour between a first steer wheel (6a) and a second steer wheel (6b) thereby indicating asymmetric steer wheel adhesion, the first steer wheel (6a) being in contact with a first area which exhibits a first coefficient of adhesion and the second steer wheel (6b) being in contact with a second area which exhibits a second coefficient of adhesion, the first coefficient of adhesion being higher than the second coefficient of adhesion,

- calculating (200) a theoretical yaw parameter as a function at least of the actual speed of the vehicle and of the actual position of the control member,

- measuring (300) the actual yaw parameter using a yaw sensor (8),

- comparing (400) the actual yaw parameter with the theoretical yaw parameter,

- angling the wheel (6a) in contact with the area exhibiting the first coefficient of adhesion by an angle θ1 whereby the first steer wheel (6a) is oriented in a direction opposing the yaw and angling the wheel (6b) in contact with the area exhibiting the second coefficient of adhesion by an angle θ2 with θ2 being comprised between a value whereby the second steer wheel (6b) is oriented substantially in the vehicle direction of travel and a value whereby the second steer (6b) wheel is oriented towards the first steer wheel (6a), if the difference between the actual yaw parameter and the theoretical yaw exceeds a reference data.

2. The method according to claim 1 for controlling a steer-by-wire steering system of a vehicle having at least one steering axle having at least two steer wheels (6a, 6b), said steering system comprising in particular:

- at least one sensing means (3) capable of detecting the position of a control member,

- at least two actuators (5a, 5b) capable of acting respectively on each of the steer wheels (6a, 6b) in order to orient said steer wheel independently by an angle θ1 and an angle θ2 with respect to the longitudinal axis of the vehicle,

- processing means able to receive an input signal originating from the sensor and able to emit an output signal bound for each of the actuators,

characterized in that the method comprises the steps of:

- detecting (100) a difference in behaviour between a first steer wheel (6a) and a second steer wheel (6b) thereby indicating asymmetric steer wheel adhesion, the first steer wheel (6a) being in contact with a first area which exhibits a first coefficient of adhesion and the second steer wheel (6b) being in contact with a second area which exhibits a second coefficient of adhesion, the first coefficient of adhesion being higher than the second coefficient of adhesion,

- calculating (200) a theoretical yaw parameter as a function at least of the actual speed of the vehicle and of the actual position of the control member,

- measuring (300) the actual yaw parameter using a yaw sensor (8),

- comparing (400) the actual yaw parameter with the theoretical yaw parameter,

- acting on the actuator (5a) of the first steer wheel (6a) in contact with the area exhibiting the first coefficient of adhesion in order to angle the steer wheel (6a) by an angle θ1 such that the first steer wheel (6a) is oriented in a direction opposing the yaw; and acting on the actuator (5b) of the second steer wheel (6b) in contact with the area exhibiting the second coefficient of adhesion in order to angle the wheel (6b) by an angle θ2, with θ2 being comprised between a value whereby the second steer wheel (6b) is oriented substantially in the vehicle direction of travel and a value whereby the second steer (6b) wheel is oriented towards the first steer wheel (6a), if the difference between the actual yaw parameter and the theoretical yaw exceeds a reference data.

3. The method according to claim 1 or claim 2, characterized in that the step of detecting the difference in adhesion between the two steer wheels (6a, 6b) is performed while the vehicle is under braking.

4. The method according to one of the claims 1 to 3, characterized in that the angle θ2 formed by the steer wheel (6b) exhibiting a second coefficient of adhesion and the longitudinal axis of the vehicle is nil.

5. The method according to one of the claims 1 to 4, characterized in that the angle θ2 formed by the steer wheel (6b) exhibiting the second coefficient of adhesion and the longitudinal axis of the vehicle is oriented in a direction equal to the direction of the yaw speed and is greater than 0.

6. The method according to claim 5, characterized in that the angle θ1 formed by the steer wheel (6b) having the first coefficient of adhesion and the longitudinal axis of the vehicle and the angle θ2 formed by the steer wheel in contact with the surface having the second coefficient of adhesion and the longitudinal axis of the vehicle are oriented in opposite directions and have the same magnitude.

7. The method according to claims 1 to 6, characterized in that it comprises the step of modifying the initial angles θ1i and θ2i formed respectively by the steer wheels (6a, 6b) with the longitudinal axis of the vehicle by respectively θ1 and θ2.

8. The method according to claims 2 to 7, characterized in that the step of detecting a difference in behaviour thereby indicating asymmetric steer wheel adhesion, one wheel being in contact with an area having a first coefficient of adhesion and one wheel being in contact with a surface of low adhesion, is performed using the speed sensors of each of the steer wheels of an antilock braking (ABS) system

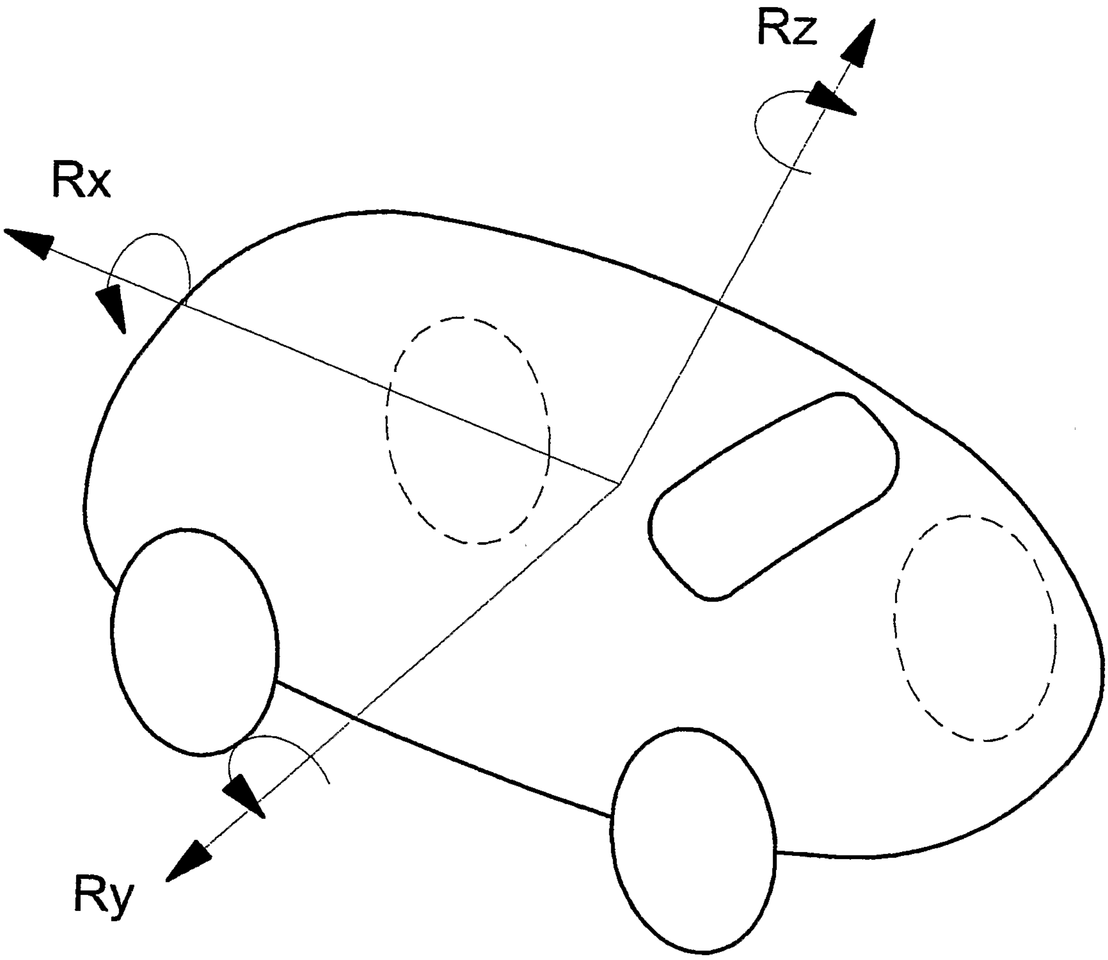


Fig. 1

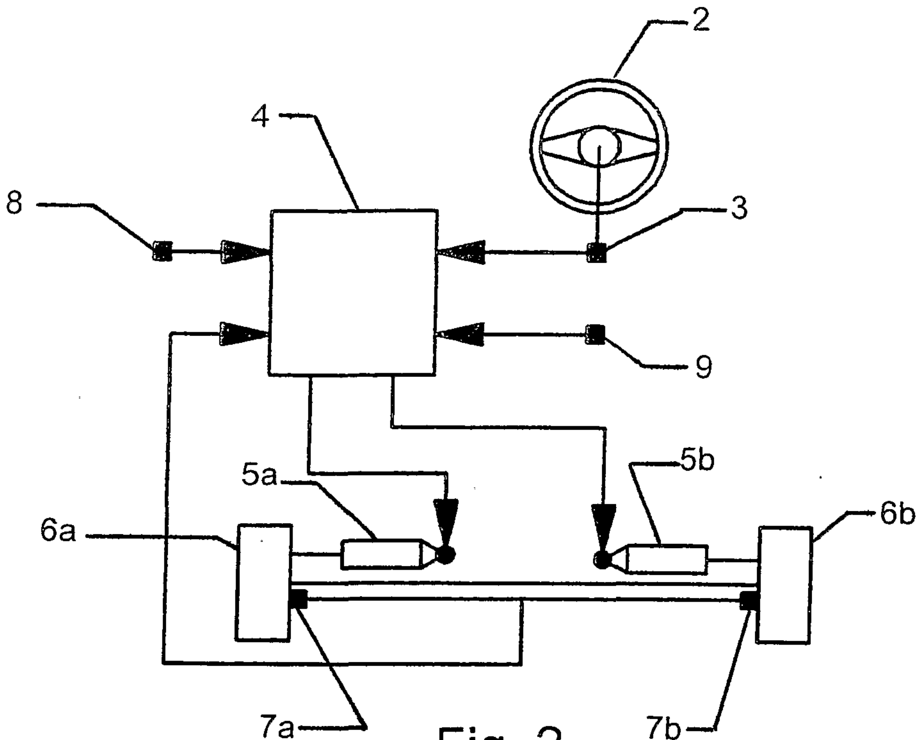


Fig. 2

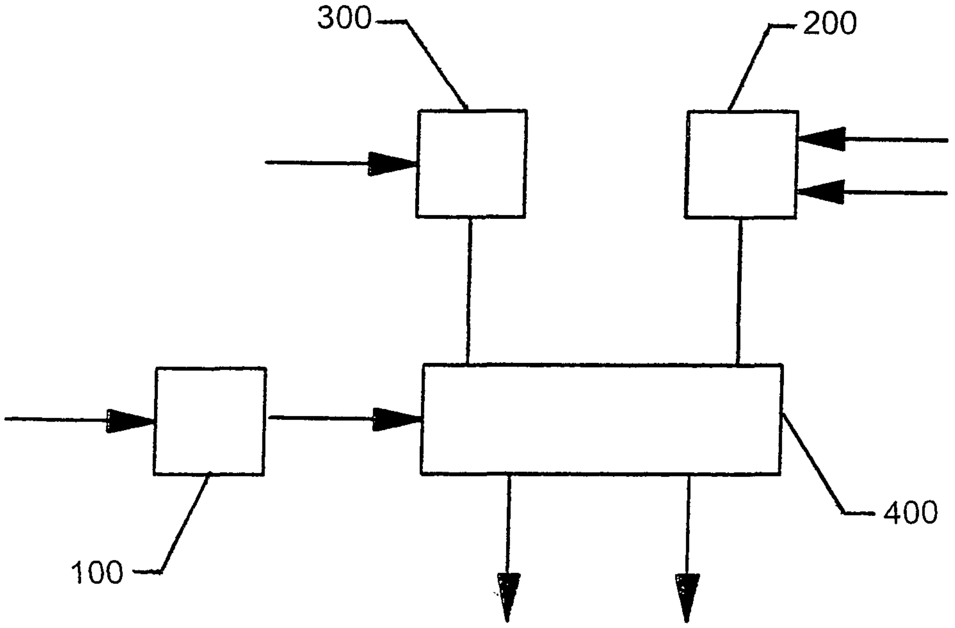


Fig. 3

Fig. 4

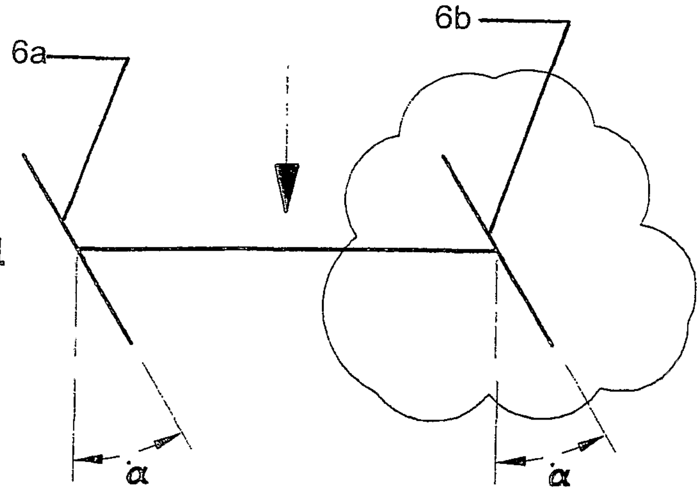


Fig. 5

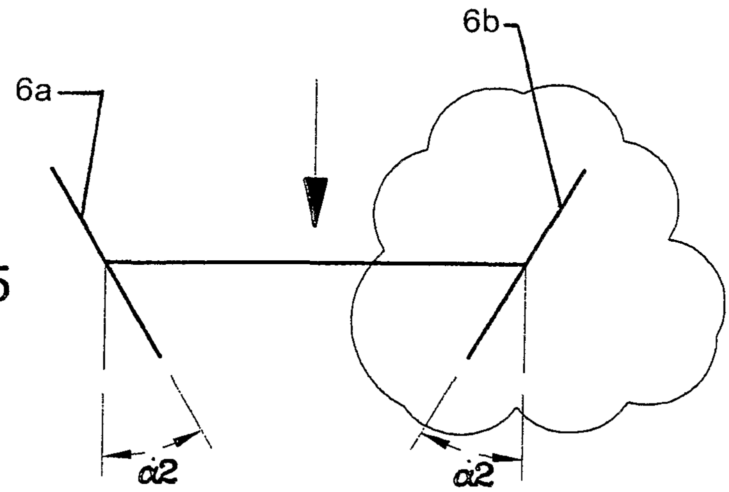
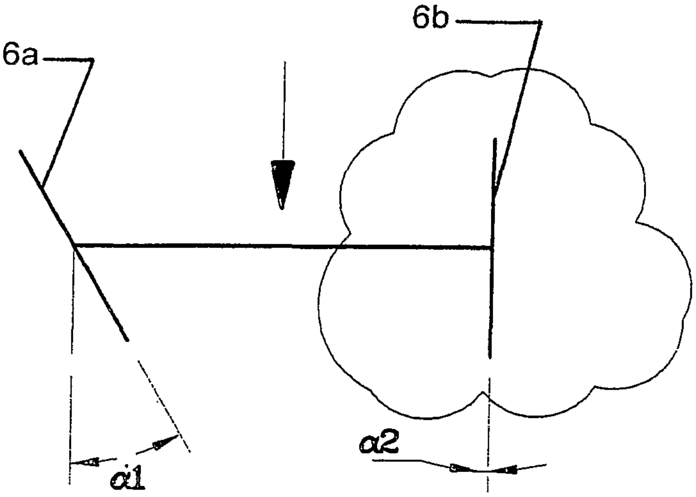


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2005/003646

A. CLASSIFICATION OF SUBJECT MATTER
B62D7/09 B62D9/00

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)
B62D

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 219 604 B1 (DILGER ELMAR ET AL) 17 April 2001 (2001-04-17) the whole document column 4, line 29 - column 5, line 55; figure 4	1
A	US 6 795 761 B1 (LEE HYEONGCHEOL ET AL) 21 September 2004 (2004-09-21) the whole document	1
A	US 6 757 601 B1 (YAO YIXIN ET AL) 29 June 2004 (2004-06-29) the whole document	1
A	EP 1 110 835 A (FORD GLOBAL TECHNOLOGIES, INC; FORD GLOBAL TECHNOLOGIES, LLC) 27 June 2001 (2001-06-27) the whole document	

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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 document 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	Date of mailing of the international search report
22 March 2006	30/03/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Van der Veen, F

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2002/030407 A1 (NISHIZAKI KATSUTOSHI ET AL) 14 March 2002 (2002-03-14) the whole document	1
A	US 6 226 581 B1 (REIMANN GERD ET AL) 1 May 2001 (2001-05-01) the whole document	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2005/003646

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 6219604	B1	17-04-2001	JP	2000198453	A	18-07-2000
US 6795761	B1	21-09-2004	NONE			
US 6757601	B1	29-06-2004	DE	102004001320	A1	05-08-2004
EP 1110835	A	27-06-2001	DE	60023640	D1	08-12-2005
			JP	2001219840	A	14-08-2001
			US	6263261	B1	17-07-2001
			US	2002095244	A1	18-07-2002
			US	2001008986	A1	19-07-2001
US 2002030407	A1	14-03-2002	DE	10127592	A1	03-01-2002
			FR	2810608	A1	28-12-2001
			JP	3655172	B2	02-06-2005
			JP	2002002474	A	09-01-2002
US 6226581	B1	01-05-2001	WO	9901320	A1	14-01-1999
			EP	0920389	A1	09-06-1999
			JP	2001500821	T	23-01-2001