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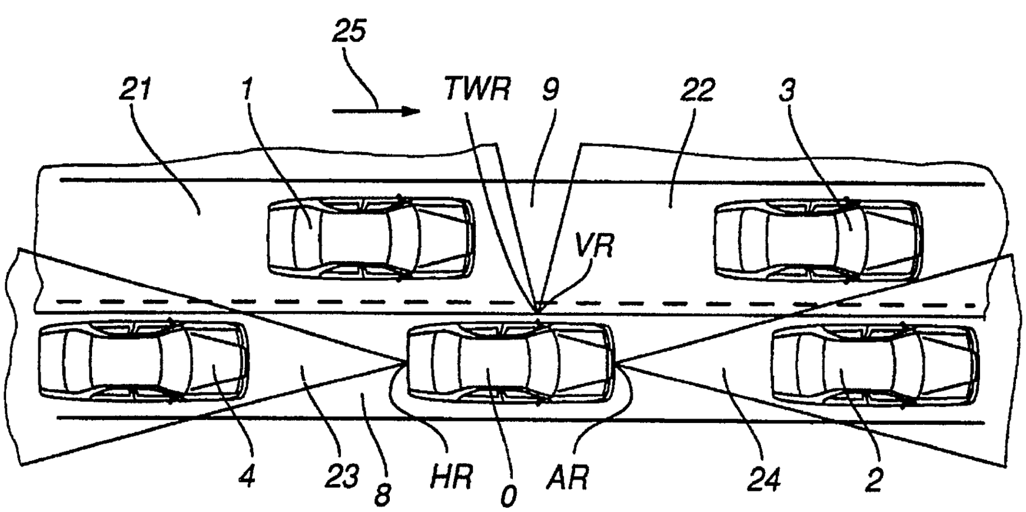
(54) **Assistance for vehicle changing lane**

(57) A method for providing guiding assistance for a motor vehicle in changing lane from a current lane 8 to an adjacent target lane 9, in which the space 22 in front and the space 21 behind at least in the adjacent target lane for the desired lane change is monitored by radius, the distance s01, s02, s03 and so4, fig. 2) from objects, in particular vehicles, detected there, and their speeds are measured and safety distances (sw01, sw02, sw03 and sw04) calculated therefrom. If all the measured distances are greater than the calculated safety distances, this is detected as a possible immediate lane change. If an immediate lane change is not possible, the target lane is checked for gaps in the traffic stream which are longer than the sum of the forward (sw03) and rearward (sw01) safety distances appertaining to that lane. The driver is thus relieved to the greatest possible extent of the task of monitoring and estimating distances and speeds of vehicles which are travelling behind and travelling in front.

Fig. 7



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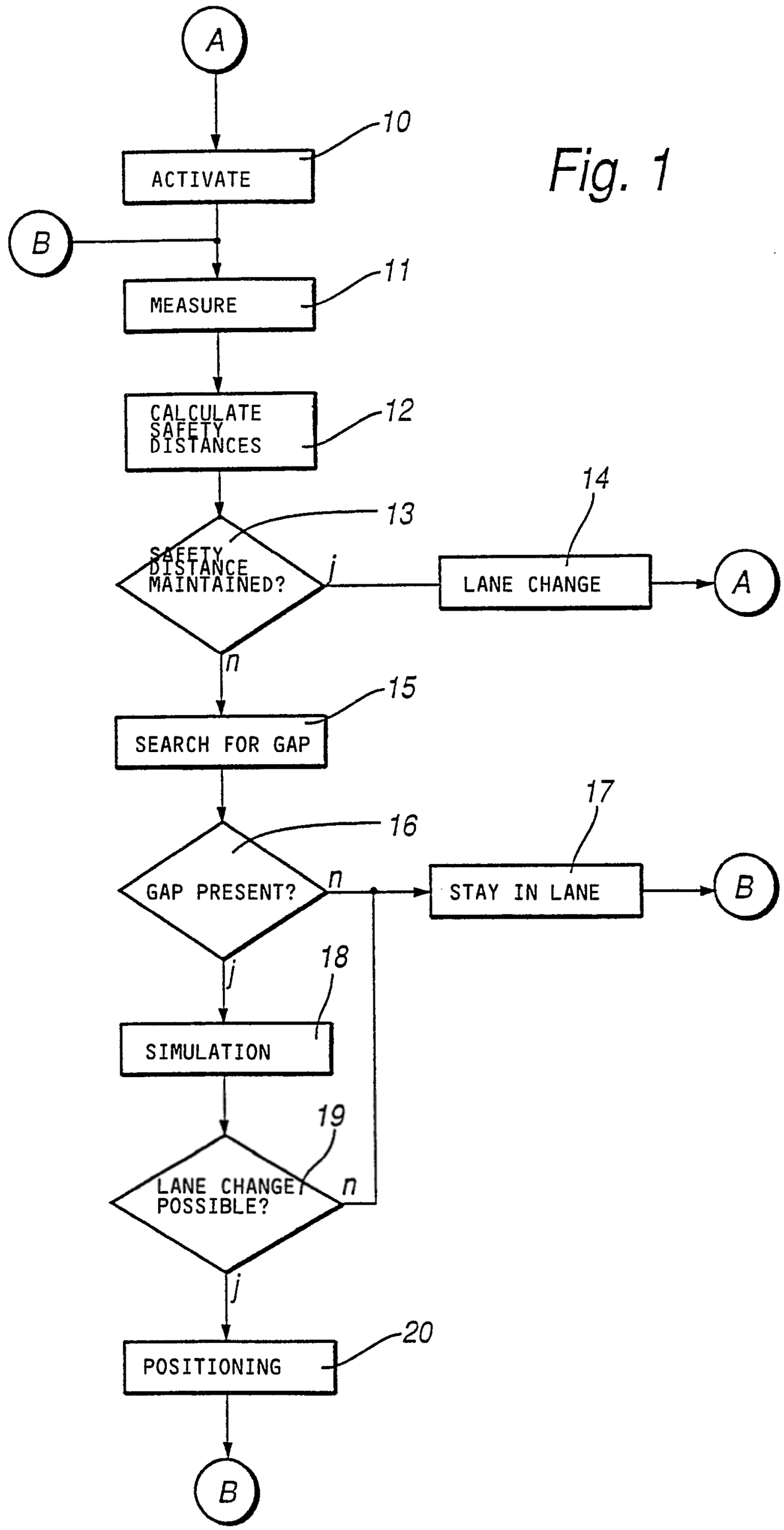
A
ACTIVATE
10
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MEASURE
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CALCULATE SAFETY DISTANCES
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SAFETY DISTANCE MAINTAINED?
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LANE CHANGE
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SEARCH FOR GAP
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GAP PRESENT?
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SIMULATION
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LANE CHANGE POSSIBLE?
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POSITIONING
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Fig. 1

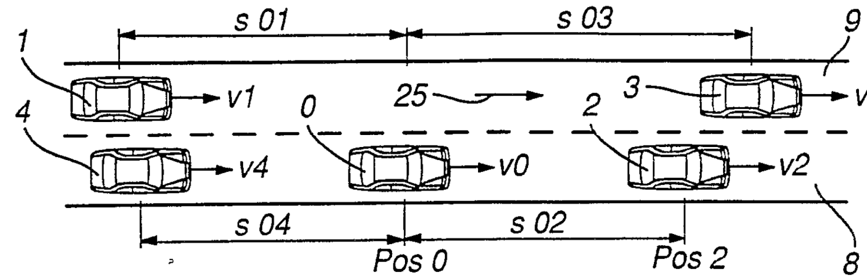


Fig. 2

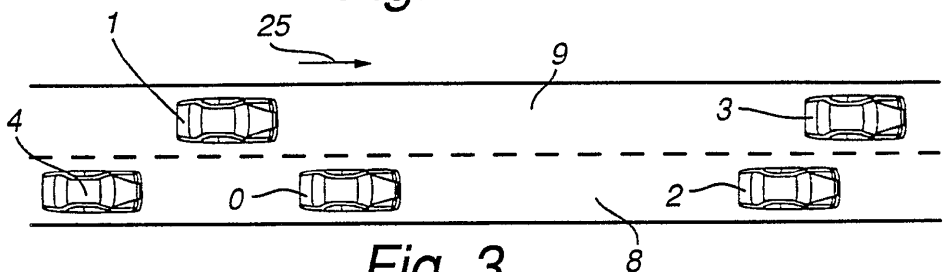


Fig. 3

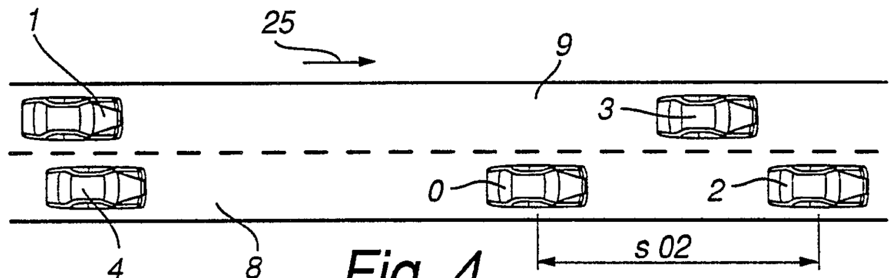


Fig. 4

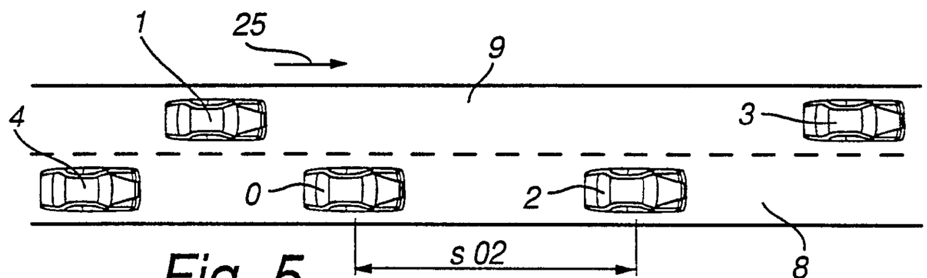


Fig. 5

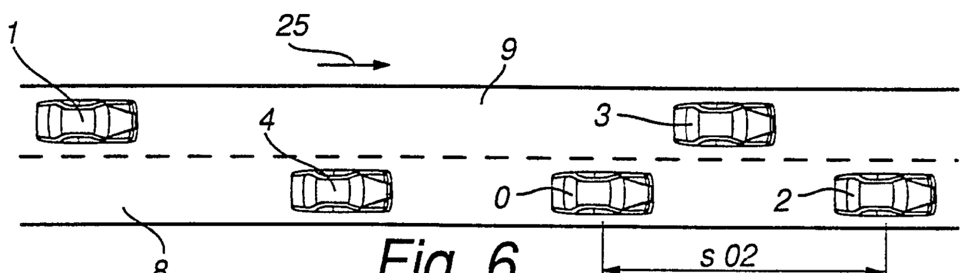
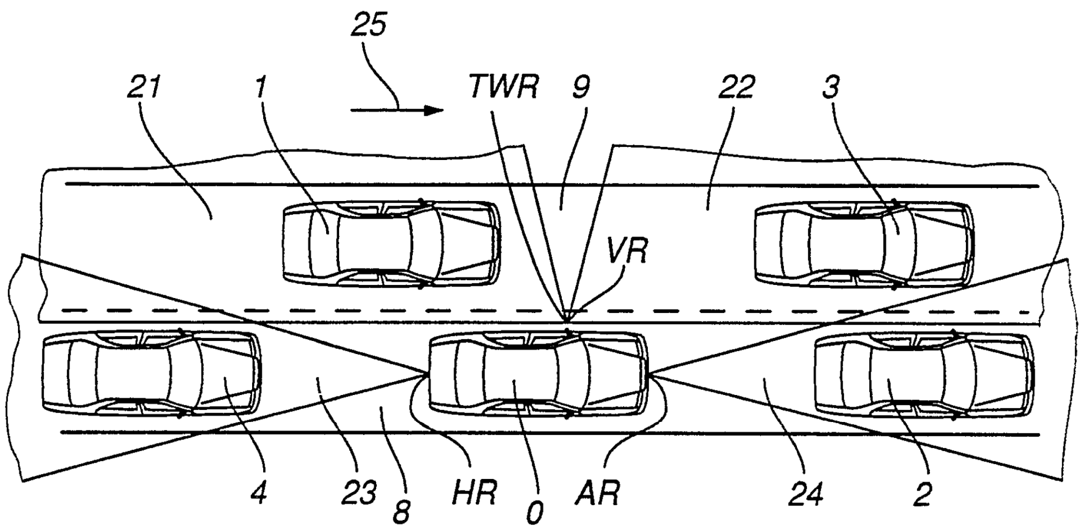


Fig. 6

Fig. 7



Method for providing guiding assistance for a vehicle in changing lane

The invention relates to a method for providing guiding assistance for a vehicle in changing lane from a current lane to an adjacent target lane.

A method of this kind serves to support the driver of the motor vehicle when changing lane, for example to feed into or leave a motorway or to overtake a slower vehicle, that is to say to at least partially relieve him of the monitoring measures required for this and to assist him, by evaluating the data acquired during the monitoring, in the decision as to whether a risk-free lane change is possible.

Such a method is disclosed for example in DE 40 05 444 A1. In this publication, the space behind the vehicle is monitored for the presence of objects, that is to say principally of vehicles travelling behind, and the distance from, and speed of, objects detected in this area are determined. From this, the deceleration which may have to be performed by a vehicle travelling behind when the driver's own vehicle which is travelling in front changes lane is calculated and an associated evaluation index is formed, the incremental values of which index are displayed to the driver. As a result, the latter receives audible or visual information on a possible lane change graded according to the expected adverse effect on the traffic behind. A laser-impulse distance measuring device serves to monitor the space behind.

Furthermore, in addition to ultrasonic and infrared systems (see for example DE 38 32 720 A1, in particular radar devices are known as monitoring detectors. The latter are, in addition to their use for monitoring the so-called blind-spot area (see for example DE 39 02 852 A1, used principally for measuring distances from vehicles travelling ahead, thus for example for driving with automatic distance control (see for example F. Ackermann, Distance Control Using Radar, Spektrum d. Wiss., June 1980, pp. 25 et seq. or for acquiring overtaking recommendations such as in the case of DE 36 22 447 C1, in which monitoring of the space in front by radar is provided for this purpose.

DE 36 22 091 A1 discloses a lane change warning system in which a monitoring detector can be switched over between monitoring of a blind-spot area and monitoring of a space in front, the monitoring of the blind spot behind being selected during a lane change warning mode of operation and the monitoring of the space in front being selected in a distance warning operation mode of coupled to the switching of a fog lamp.

DE 30 28 077 C2 discloses a device for warning the vehicle driver of a vehicle travelling ahead of him in the current lane, in which case the space in front in the current lane is monitored by means of a radar device for the presence of a vehicle travelling ahead and the distance of the driver's own vehicle from a detected vehicle travelling ahead and its relative speed is determined. As a function of these parameters and the speed of the driver's own vehicle and, if appropriate, further parameters such as the state of the carriageway and brakes, a safety distance between the two vehicles is calculated which is then compared with the measured distance. If the measured distance is smaller than the safety distance, a warning signal is produced and/or the risk of an impact is displayed on a visual display panel. In a variant of this known device, there is additional provision for the risk of a collision to be expected in the event of changing lane to be indicated, in that as well as the space in front in the current lane, the respective space behind on adjacent lanes is additionally monitored and the detected data are evaluated in a manner analogous to that for the vehicle travelling ahead in the current lane. Consequently, for the evaluation of a possible lane change this device only takes into account the respective current situation in the space behind in a possible target lane.

The invention is based on the technical problem of providing a method for providing guiding assistance for a motor vehicle when changing lane, which method is capable of deciding automatically as to the possibility of an instantaneous or future lane change and largely relieves the driver of the task of observing the surroundings and estimating distances and speeds.

According to the present invention there is provided a method for providing guiding assistance for a motor vehicle in changing lane from a current lane to an adjacent target lane, including the following steps:

a both the space behind and the space in front in at least the adjacent target lane is monitored by means of detectors for the presence of objects and the speeds of the detected objects and of the driver's own vehicle and the distances of the detected objects from the driver's own vehicle are determined,

b safety distances of the driver's own vehicle from each of the detected objects are calculated as a function of the speed data acquired in the previous step, a reaction time and given deceleration values are calculated,

c the measured distances are compared with the calculated safety distances for each object and either

d.1 a possible lane change is signalled if the calculated safety distance for all the objects is greater than, or at least the same size as, the measured distance, or

d.2 a search for gaps is carried out if, for at least one object the measured distance is smaller than the calculated safety distance, in the following steps:

d.2.1 at least the sum of the measured distances of the driver's own vehicle from the object in the space behind and from the object in the space in front in the target lane is compared with the corresponding sum of the calculated safety distances and

d.2.2 it is signalled that a lane change is not excluded if at least one sum of the measured distances is greater than the corresponding sum of the calculated safety distances and, otherwise, it is signalled that a lane change is excluded.

By monitoring with detectors both the space behind and the space in front in the target lane and by acquiring the required distance and speed data of the objects detected there, above all vehicles, this method is capable of detecting whether a sufficient gap is present in the target lane for a desired lane change, specifically taking into account risk-preventing safety distances to be observed. The driver does not need to keep an eye on the space behind nor the space in front in the target lane nor does he need to estimate the distances and speeds of the vehicles in it. He is informed by appropriate warning indications and/or instructions from the computer-controlled guiding assistance method of the presence of a sufficient gap in the target lane in the case of a desired lane change. Here, the search for a gap according to the invention permits it to be detected whether, if possibly not in the current vehicle situation, a gap is at all in principle available in the target lane for a lane change. Thus, it is possible to detect the presence of a gap, permitting a lane change, in the target lane obliquely in front of, or obliquely behind the driver's own vehicle, and to indicate this to the driver. The said driver can then attempt by means of suitable manoeuvres, that is to say in particular acceleration or deceleration of his vehicle, to position himself level with this gap indicated to him by the guiding assistance method and subsequently to carry out the lane change. This relieves the driver of the vehicle in a particularly advantageous manner of the tasks of observing and evaluating the driving situation in the space in front and behind in the target lane.

In a preferred embodiment, in step a the space behind and the space in front in the target lane is additionally monitored by means of detectors for the presence of objects and the further steps are also carried out in relation to the objects detected there, in which case, in order to carry out the search for gaps in step d.2.1, additionally

- the sum of the measured distances from the object in the space behind in the target lane and from the object in the space in front in the current lane is compared with the corresponding sum of the calculated safety distances and
- the sum of the measured distances from the object in the space behind in the current lane and from the object in the space in front in the target lane is compared with the corresponding sum of the calculated safety distances, and in step d.2.2
- it is signalled that a lane change is not excluded if in all three cases the sum of the measured distances is greater than the corresponding sum of the calculated safety distances and, otherwise, it is signalled that a lane change is excluded., vehicles in the current lane, that is to say the lane in which the driver's own vehicle is located before a lane change, are also included by the method as factors to be considered. The search for a gap which is further developed in this way does not only detect whether a gap is in principle present in the target lane but also additionally whether the position in the current lane, that is to say vehicles which may be located there in the space in front or behind, permits such a gap to be reached by the driver's own vehicle so that the driver is also relieved of this task of evaluating the driving situation in the current lane.

Advantageously, the question as to whether a detected gap, which is in principle sufficient for a lane change, in the target lane can in practice even be reached by the driver manoeuvring his car can also be answered by the guiding assistance method in that the possible future driving behaviour for reaching the gap is played through in a computer simulation and tested as to whether the gap is actually reachable. In a further development of this idea, the necessary acceleration or deceleration values, which are detected by the simulation in the case of a reachable lane change, for the driver's own vehicle are either displayed to the driver or, together with a further increase in driving comfort, passed on directly to a longitudinal movement controller device, which is possibly present, of the vehicle, which device is capable of automatically controlling the movement of the vehicle in the direction of travel without the intervention of the driver.

A particularly high level of driving comfort with respect to the control of the vehicle can be achieved with a further embodiment of the invention in which it is signalled to a transverse movement controller device, which may be present, of the vehicle that a gap which permits a lane change has been reached and the said transverse movement controller device automatically causes the vehicle to move out in the target lane and to be fed into the gap in the target lane without the driver having to perform steering movements himself. In conjunction with a longitudinal movement controller device which is actuated simultaneously, a method for completely autonomous vehicle control including possible lane changes is realized without controlling interventions of the driver being required.

An advantageous embodiment of the invention is illustrated in the drawings and described below by way of example. In the said drawings:

Fig. 1 shows a programme sequence plan of a computer-controlled guiding assistance method for a lane change,

Figs. 2 to 6 show different vehicle situations in order to illustrate the guiding assistance method and

Fig. 7 shows a diagrammatic illustration of the monitored areas used by the method.

In the illustrations of carriageways in Figs. 2 to 7, in each case a vehicle 0 is shown in a current lane 8 with a vehicle 2 travelling ahead in this current lane 8 and a vehicle 4 following, and in a target lane 9 a front vehicle 3 and a rear vehicle 1 are shown, the direction of travel being indicated in each case by the arrow 25. In Fig. 2, the respective distances s01, s02, s03, s04 of the driver's own vehicle 0 from the four other vehicles 1, 2, 3, 4 are entered.

It is clear from Fig. 7 that the driver's own vehicle 0 has a rear-mounted radar device HR for monitoring the space 23 behind in the current lane 8, a distance radar device AR for monitoring the space 24 in front in the current lane 8, a blind-spot radar device TWR for monitoring the space 21 behind in the adjacent target lane 9 and a forward-directed radar device VR for monitoring the space 22 in front in the target lane 9. These detector devices detect the presence of objects in the area respectively covered by them and also permit the distance from the object to be determined. The term object here includes other vehicles and stationary obstacles which may be encountered, for example at the end of a lane. The blind-spot radar and the forward-directed radar TWR, VR are integrated in the exterior mirrors. The angle of the radar lobe is sufficiently large to reduce the blind spot. The monitoring of the space behind requires a range of the blind- spot radar in the longitudinal direction of at least approximately 100 m.

The mode of operation of the method for computer-assisted guiding assistance for a driver's motor vehicle 0 when changing lane from the current lane 8 to the adjacent target lane 9, which in the case shown constitutes an overtaking lane located to the left of the current lane 8 in the direction of travel, is explained in detail below with reference to the programme sequence plan of Fig. 1.

The method is initiated by means of an activation step 10 which is formed by a travel direction indicator lever being activated. The system is thus activated simultaneously with the triggering of the travel direction indicator. As an alternative there may be provision for the method to be activated by simply tapping the travel direction indicator lever without the travel direction indication being triggered so that the other road users are not confused by the intention of a possibly momentary but not yet realizable lane change. The travel direction indication is not issued until a gap is detected for a possible lane change and the driver's own vehicle has reached the position required for the lane change. This actuation is preferably cancelled if it has not been possible to find a gap within a predetermined time, after which the driver is requested to repeat it if he still intends to change lane. If, on the other hand, the other road users are informed of the imminent intention of a lane change by the immediate lighting up of the travel direction indicator, the other road users may react differently, either by leaving space for a sufficient gap or else by closing a gap which may be present and thus making a lane change impossible.

A further alternative consists in the vehicle-mounted system, which carries out the method, remaining continuously activated and only the data output to corresponding display devices or vehicle movement-controlling devices is actuated in each case by the request for an indication of a change in travel direction. In this procedure, the computer and the data lines are continuously occupied and ready. If, on the other hand, the system which carried out the method is only activated in each case in response to the request for a travel direction indication, as a result it can be used in the meantime for other purposes also. It is to be noted at this point that the method can be carried out by means of a customary vehicle-mounted computer system, such as is known for example for the purpose of automatic distance-controlled driving, for which reason a detailed description of the system components is dispensed with here.

The request for the activation of the travel direction indicator can be communicated to the driver, if desired, by the forward-directed monitoring in the current lane 8 if it is detected during this process that there is an object 2 in this area 24 in front which is moving more slowly in the direction of travel than the driver's own vehicle 0.

After activation, in a following step 11 the distances s01, s02, s03 and s04 from the objects 1 to 4 which are detected in the monitored areas 21 to 24 and their relative speeds with respect to the driver's own vehicle 0 are measured from the driver's own vehicle by means of the radar devices and the driver's own speed v0 is determined by means of the speedometer. In order to retain the data of these variables, the raw data of the radar devices are preprocessed here according to their purpose, faults for example due to signal reflections are filtered out and sufficient plausibility tests are carried out. For example, the objects 1 to 4 detected when cornering are assigned to the respective lane by means of the steering angle. If the relative speed of an object is equal and opposite to the speed of the driver's own vehicle, this object is interpreted as a stationary obstacle or the end of a lane, for example a feeding-in lane. If contradictory signals occur which cannot be evaluated, this is indicated to the driver if he has actuated the travel direction indicator. Vehicles travelling in the opposite direction on an oncoming carriageway can be blanked out or a warning signal can be triggered when the travel direction indicator is actuated.

In a following step 12, the safety distances sw01, sw02, sw03 and sw04 are calculated from the distance and speed data acquired in the previous step. For this purpose, initially the absolute speeds v1, v2, v3 and v4 of the other vehicles and detected objects 1 to 4 are calculated from the relative speeds and the vehicle's own speed v0. Subsequently, the safety distances are formed in each case as a sum from a reaction distance, a residual distance, a braking distance differential and a distance for coasting to a standstill.

The reaction distance is obtained from the product of a reaction time and the speed of the respective vehicle behind. A customary driver's reaction time, for example 1.8 s, can be set for the reaction time. When starting a distance control, the shortest system reaction time can be used at this point. The residual distance forms a safety margin and is typically set at approximately 5 m. Braking distance differential is understood to be the difference between the braking distances for full braking of the two vehicles between which the safety distance has just been detected, the maximum deceleration, for example typically 3 m/s^2 being specified or, if the driver's own vehicle 0 has appropriate devices, being determined automatically by means of the coefficient of friction dependent on the state of the road. Finally, the distance for coasting to a standstill is obtained from non-driven rolling of the vehicles with a reasonable deceleration which is typically 1 m/s^2. With these specified parameters of which, incidentally, the residual distance and the reaction time can be matched by means of an adaptive control, the computer of the system calculates the safety distances sw01 to sw04 of the driver's own vehicle 0 from each of the detected objects or vehicles 1 to 4.

In a following step 13 an interrogation takes place as to whether the safety distances have all been maintained, in that the measured distances s01 to s04 are compared with the calculated safety distances sw01 to sw04. If the driver's own vehicle 0 has a distance controller device, for example in conjunction with a speed control, the safety distance sw02 from the vehicle 2 travelling ahead in the current lane 8 is automatically maintained and it is only necessary to check the other distances. If the computer determines that all the measured distances are greater than or at least the same size as the respectively associated calculated safety distances, it signals that a lane change can be realized in the current situation and indicates this to the driver appropriately. He can then carry out the lane change in a following step 14, after which the system returns again to the point A before the actuation of the system.

When carrying out this method step it may be advantageous not to use precisely calculated limits of the safety distance but rather, in particular during a lane change, to execute the distance boundaries according to a plausibility test somewhat imprecisely or to provide them with hysteresis properties. Furthermore, the inclusion of acceleration processes, which have already been started, of individual vehicles in the calculation of the safety distances can be useful to the flow of traffic.

If, on the other hand, the computer has calculated that one of the measured distances is smaller than the associated safety distance, this means that a current lane change is not possible. The method programme then provides a search for a gap as the next step 15. During this, it is determined whether a gap which is sufficient for a lane change, if it is not already at the level of the current position of the driver's own vehicle 0 is possibly located obliquely in front of or obliquely behind the driver's vehicle 0 and is basically also accessible to the driver's vehicle 0. For this purpose, the following measured distances and calculated safety distances are summed and compared by the computer. Firstly, the sum s01 + s03 of the measured distances from the vehicles 1, 3 in the target lane 9 and the sum sw01 + sw03 of the associated calculated safety distances. The computer compares both sums and detects the presence of a gap in the target lane 9 if the sum of the measured distances is greater than the sum of the calculated safety distances. Secondly, it calculates the sum s01 + s02 of the measured distances between the vehicle 1 behind in the target lane 9 and the vehicle 2 which is travelling ahead in the current lane 8 and likewise in turn calculates the associated sum sw01 + sw02 of the calculated safety distances. The same is carried out as a third step with the distances of the two other vehicles 3, 4. Both sums s01 + s02, s03 + s04 of the measured distances are then in turn compared in each case with the associated sum of the calculated safety distances and if it is detected in both cases that the sum of the measured distances is greater than the sum of the associated calculated safety distances, this is interpreted to mean that space is available for the driver's own vehicle 0 to accelerate or decelerate, as a result of which it may be possible to reach the detected gap in order to change lane.

If, subsequently, in at least one of the three comparisons of this interrogation step 16, the sum of the measured distances is smaller than the sum of the calculated safety distances, this is interpreted to mean that under the set parameters, such as for example reaction time, safety margin, residual distance, the driver's acceleration or deceleration and reasonable deceleration of the other vehicles, a lane change is not possible. In consequence, in a following step 17, the instruction to stay in lane is issued to the driver. In the method sequence, the system then returns to point B before the measurement step 11 and from there a new run-through the method begins, during which new measurement data, which may arise from possible changes in the positions or speeds of the vehicles, are acquired.

If, on the other hand, in all three comparisons the sum of the measured distances is greater than that of the calculated safety distances, this is interpreted to mean that firstly a gap is available for a lane change and secondly this gap can also be reached, not immediately but after suitable vehicle manoeuvres have been carried out, in particular an acceleration or deceleration process. This can be signalled to the driver by the system, for example by means of an LED.

The method provides extensive assistance to the driver in dealing with the problem which then occurs as to how he can reach by means of suitable manoeuvres with his own vehicle 0 the gap which is basically present in the target lane 9, in which case changes in the driving behaviour of the other vehicles 1 to 4, for example accelerations, decelerations or lane changes, are currently taken into account. For this purpose, subsequently, there is provision for a simulation step 18 after a positive response in the preceding interrogation step 16 which enquired whether a gap was basically present. In this process, the future procedure until the gap is reached is played through in a computer simulation with all the vehicles 0, 1, 2, 3, 4 because it is a highly non-linear problem, since a change in the vehicle's own speed means at the same time a change in the calculated safety distances. Even when the speed of the other vehicles is constant, such an increase in the vehicle's own speed v0 can occur that when the gap remains the same size the safety distances from the vehicles travelling ahead may no longer be maintained or that the specified acceleration is not sufficient to carry out the change in position within a period in which the change in traffic situation permits a lane change. In both cases, an initiated overtaking process would have to be aborted, for which reason the simulation which is calculated in advance in the time accelerator is appropriate at this point. The radar devices according to Fig. 7 detect here the currently occurring traffic situation with the distances and speeds of the other vehicles. On the basis of this situation, it is played through in the simulation whether, and by means of which activities, it may become possible for the driver to feed into the gap which has been found.

For this simulation, a negative acceleration value, that is to say a deceleration, is prescribed if the calculated safety distances from the vehicles 1, 4 behind are both maintained. If, on the other hand, the safety distances from the two front vehicles 2, 3 are maintained by the measured distances, a positive acceleration value, that is to say an actual acceleration, is prescribed. Thus, the traffic behaviour is simulated in advance, specifically in the longest case until, when accelerating, the distance from the vehicle 2 travelling ahead in the current lane 8 or, when decelerating, the distance from the vehicle 4 following in the current lane 8 drops below the respective associated safety distance. If the existing gap is not reached by this time, when accelerating a new simulation cycle with an incrementally increased acceleration value is carried out.

The interrogation step 19 as to a possible lane change, on accelerating, is not ultimately answered negatively, and the driver in turn given the instruction in step 17 to stay in lane, until it has not been possible to reach the gap after a set upper limit for the acceleration value, which results for example from the smallest value of the engine output threshold, the threshold of the coefficient of friction or an individual comfort threshold, has been reached or after a prescribed maximum speed has been reached. On the other hand, for reasons of driving comfort the deceleration in the simulation is not increased incrementally but set right at the beginning to a value which is still advantageous for comfort. If the gap is not reached after the single deceleration simulation cycle, the instruction to stay in lane is issued to the driver again.

If, on the other hand, during the simulation, it is detected in the interrogation step 19 that a lane change is possible by means of the simulated vehicle manoeuvre, the data detected for this, relating to the vehicle acceleration or deceleration, are output. These data are output on the one hand to a display device for the driver, who can subsequently set the required acceleration or deceleration value and then perform the manoeuvre to reach the gap in the target lane under his own control. This realization of the previously simulated vehicle manoeuvre is described with step 20 of the positioning in the programme sequence plan in Fig. 1. If the vehicle has a longitudinal movement controller device for automatic movement of the vehicle in the longitudinal direction, the data can be output, on the other hand, to this longitudinal movement controller which then automatically moves the vehicle onto the acceleration or deceleration value detected in the simulation. After the transfer of data, the system returns to point B before the measurement step 11 from where the method is run through again in order finally to detect that the sufficient gap has been reached and to be able to perform the desired lane change.

A completely autonomous vehicle control including lane changes without any intervention of the driver being necessary is possible if the vehicle additionally has a transverse movement controller device. Then, when it is detected that a lane change is possible, this same possibility is signalled to the transverse movement controller after which the lane change is carried out automatically by the longitudinal movement controller and transverse movement controller of the vehicle, possibly after an appropriate request from the driver.

The method is explained below applied to different traffic situations according to Figs. 2 to 6.

Fig. 2 shows an example in which it is presumed that all the safety distances are maintained. The execution of the method described above results in the gap in the adjacent, here left-hand target lane 9, and thus the possibility of an immediate lane change, are detected.

In the case in Fig. 3, the safety distance from the vehicle 1 behind in the target lane 9 is not maintained and the system which carries out the method thus detects that an instantaneous lane change is not possible. However, the gap search step 15 leads to a positive response to the question of a gap being basically present which is located obliquely in front of the driver's own vehicle 0. The measured distance from the vehicle 2 travelling ahead in the current lane 8 gives rise to a free distance for acceleration. In the subsequent simulation, it is played through whether, and if so with what acceleration, it is possible to position the vehicle in this gap at a safe distance from all the other vehicles.

In the traffic situation according to Fig. 4, the safety distance from the vehicle 3 travelling ahead in the target lane 9 is not maintained. The system which carries out the method detects in turn that an immediate lane change is not possible. The subsequent search for a gap gives rise to a positive response to the question of a gap being basically present which in this case is located obliquely behind the driver's own vehicle 0. The measured distance from the vehicle 4 travelling behind in the current lane 8 turns out to be considerably greater than the calculated safety distance, which indicates a free distance for deceleration. In the subsequent simulation, it is played through whether it is possible to position the vehicle in the gap at a safe distance from the other vehicles by means of the preselected deceleration or by simply waiting.

In the case in Fig. 5, as in the case in Fig. 3, the presence of a gap is in turn detected obliquely in front of the driver's own vehicle 0. The distance from the vehicle 2 travelling ahead in the current lane 8 corresponds, however, approximately to the calculated safety distance, for which reason there is no distance free for acceleration so that the question of a possible lane change in step 19 has to be answered negatively and the instruction to stay in the current lane 8 is issued to the driver.

In the situation in Fig. 6, as in the case in Fig. 4, the presence of a gap obliquely behind the driver's own vehicle 0 is detected. However, the measured distance from the vehicle 4 travelling behind in the current lane 8 corresponds already approximately to the calculated safety distance so that there is no free distance for deceleration remaining and the question of a possible lane change is again answered negatively so that in this case the vehicle also has to stay in the current lane 8.

The method can of course, as to a certain extent already indicated, be used in conjunction with distance-controlled driving and a speed controller. In the same way as for changing into a left-hand target lane, a lane change to the right-hand target lane can be brought about by the method if the driver's own vehicle has appropriate radar detection devices on the right-hand side, the actuation then taking place in response to the request for an indication of a change in travel direction to the right. Usually, the speeds of the vehicles in the right-hand target lane are lower, for which reason, as a modification in the computer simulation, a deceleration is then preselected if the current speed of the driver's own vehicle is higher than the speed preselected on a speed controller.

Furthermore, it is possible, on multi-lane roads such as for example highways in the USA on which overtaking on the right is permitted, for the method to detect, by means of the simulation via the computer, the lane which is currently the most suitable one for overtaking and to propose this to the driver or to the transverse movement controller device of the vehicle which may be present.

CLAIMS

1. A method for providing guiding assistance for a motor vehicle in changing lane from a current lane to an adjacent target lane, including the following steps:

a both the space behind and the space in front in at least the adjacent target lane is monitored by means of detectors for the presence of objects and the speeds of the detected objects and of the driver's own vehicle and the distances of the detected objects from the driver's own vehicle are determined,

b safety distances of the driver's own vehicle from each of the detected objects are calculated as a function of the speed data acquired in the previous step, a reaction time and given deceleration values are calculated,

c the measured distances are compared with the calculated safety distances for each object and either

d.1 a possible lane change is signalled if the calculated safety distance for all the objects is greater than, or at least the same size as, the measured distance, or

d.2 a search for gaps is carried out if, for at least one object the measured distance is smaller than the calculated safety distance, in the following steps:

d.2.1 at least the sum of the measured distances of the driver's own vehicle from the object in the space behind and from the object in the space in front in the target lane is compared with the corresponding sum of the calculated safety distances and

d.2.2 it is signalled that a lane change is not excluded if at least one sum of the measured distances is greater than the corresponding sum of the calculated safety distances and, otherwise, it is signalled that a lane change is excluded.

2. A method according to Claim 1, wherein

- in step a the space behind and the space in front in the target lane is additionally monitored by means of detectors for the presence of objects and the further steps are also carried out in relation to the objects detected there, in which case, in order to carry out the search for gaps in step d.2.1, additionally

- the sum of the measured distances from the object in the space behind in the target lane and from the object in the space in front in the current lane is compared with the corresponding sum of the calculated safety distances and
- the sum of the measured distances from the object in the space behind in the current lane and from the object in the space in front in the target lane is compared with the corresponding sum of the calculated safety distances, and in step d.2.2
- it is signalled that a lane change is not excluded if in all three cases the sum of the measured distances is greater than the corresponding sum of the calculated safety distances and, otherwise, it is signalled that a lane change is excluded.

3. A method according to Claim 1 or 2, wherein the safety distances are each calculated as the sum of a reaction distance, a braking distance differential for full braking, a distance for coasting to a standstill and a residual distance serving as safety margin.

4. A method according to Claim 2 or 3, wherein the distance from a detected object in the space in front in the current lane is kept automatically adjusted to a value which is the same as or greater than that of the calculated safety distance by means of a distance control device which acts on the acceleration and deceleration devices of the driver's own vehicle.

5. A method according to Claims 2 to 4, wherein a computer simulation of a lane change is carried out in response to a non-excluded lane change being signalled in

order to detect a possible lane change and the acceleration or deceleration of the driver's own vehicle which may be required for this.

6. A method according to Claim 5, wherein for the simulation

- a deceleration of the driver's own vehicle is selected if the measured distances of the objects in the space behind in the target lane and current lane are both greater than the corresponding calculated safety distances and
- an acceleration for the driver's own vehicle is specified if the measured distances from the objects in the space in front in the target lane and the current lane are both greater than the corresponding calculated safety distances.

7. A method according to Claim 6, wherein the simulation is repeated with acceleration or deceleration values which are increased incrementally if no possible lane change has been achieved with the previously selected value.

8. A method according to Claim 6 or 7, wherein in the event of a possible lane change which has been found by computer simulation, the detected acceleration or deceleration value is illustrated on a display device and/or passed on to a longitudinal movement controller device of the driver's own vehicle for automatic acceleration or deceleration of the same.

9. A method according to Claim 8, wherein the signalling of a possible lane change is passed on to a transverse movement controller device of the driver's own vehicle in order to move out automatically into the target lane.

10. A method according to any one of Claims 1 to 9,

wherein the method is actuated by the request for an indication of a change in travel direction and the requested indication of a change in travel direction does not take place until a possible lane change is signalled.

11. A method for providing guiding assistance for a motor vehicle in changing lane from a current lane to an adjacent target lane, substantially as described herein with reference to and as illustrated in the accompanying drawings.

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Relevant Technical Fields

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(ii) Int Cl (Ed.5) G01S 17/88, 13/93 G08G 1/123, 1/16

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8 JULY 1994

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE DATABASES WPI, INSPEC, CLAIMS, JAPIO

Documents considered relevant following a search in respect of Claims :-
ALL

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A	US 4349823 (HONDA) & DE 3028077	

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