(54) Title: A DEVICE AND A METHOD FOR ESTIMATING PARAMETERS RELATING TO VEHICLES IN FRONT
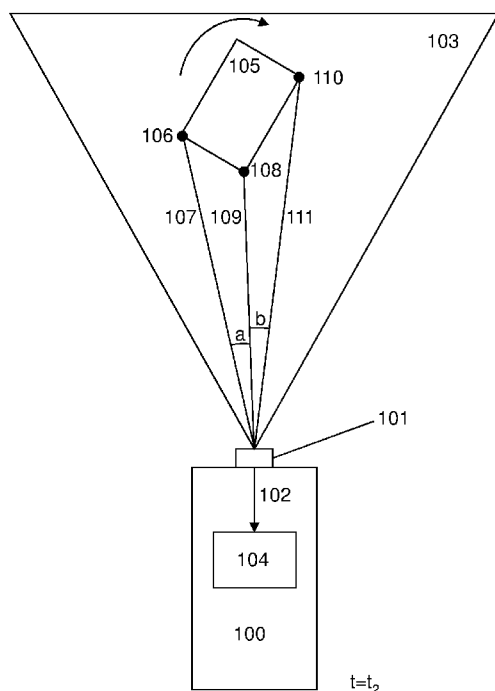
(57) Abstract: Device pertaining to a vehicle (100) for estimating parameters of objects within a region (103) in front, which device comprises at least one sensor element (101) fastened to the vehicle (100) to gather data (102) from said region in front (103) and send them to a calculation unit (104) which has a signal connection to a safety system situated in the vehicle (100) and which is adapted to calculating at least one of the parameters of angular velocity and angular acceleration for an object within the region (103) and to sending an output signal based on that calculation to one or more safety systems of the vehicle (100) when any of the parameters exceeds a predetermined limit value.

FIG. 3

WO 2012/125106 A1

WO 2012/125106 A1

A device and a method for estimating parameters relating to vehicles in front.

Field of the invention

The present invention comprises a device and a method pertaining to a vehicle, in
particular a powered road vehicle, for estimation of parameters relating to objects in
front, particularly vehicles in front. The estimation is done by means of advanced
signal processing and calculations based on data from cameras, lasers and/or radar.

Background to the invention

Various types of electronic control systems are now usual in powered land vehicles.
Control systems are to be found in, for example, automatic gearboxes, cruise
controls or other types of safety systems. The control systems usually have a
number of input data for performing their task. Input data may be vehicle-specific
parameters such as engine speed, vehicle speed or fuel consumption, but may also
be specific to surroundings, e.g. topology, imposed speed limits or distance from
vehicles in front.

For control systems which operate with input data from the vehicle's surroundings to
work satisfactorily, it is of course desirable that they receive input data which
describe those surroundings as exactly as possible. Many improvements have been
made in this field. Examples of input data which describe the surroundings and may
be given to control systems are information from alarm centres about an accident
having occurred, information from traffic centres about traffic queues or roadworks
etc. or information from other vehicles via so-called V2V (vehicle to vehicle)
communication.

US 6420996 B1 describes a method and device for predicting collisions between
vehicles with the object of preventing or mitigating the consequences of a collision,
on the supposition that the two vehicles concerned are equipped with both sensors
and transponders.

EP 1316480 B1 also describes a collision-preventing safety system, with lidar (light
detection and ranging) sensors or radar sensors whereby the safety system can be

activated when a collision with another vehicle is imminent. The sensor measures the other vehicle's position, speed and acceleration.

The object of the present invention is to propose an improved device and method for estimation of parameters relating to objects in front, particularly vehicles in front, with the object of causing the vehicle's existing safety systems to achieve greater traffic safety.

Summary of the invention

The above object is achieved with the invention defined by the independent claims. Preferred embodiments are defined by the dependent claims.

The invention thus comprises a device pertaining to a vehicle and a method for estimation of parameters relating to objects in front, particularly vehicles in front. The device according to the present invention comprises at least one sensor element for gathering data from a region in front and sending them to a calculation unit which has a signal connection to one or more safety systems situated in the vehicle and which is adapted to calculating at least one of the parameters of angular velocity and angular acceleration for an object within the region and to sending an output signal to one or more of the vehicle's existing safety systems when any of the parameters exceeds a predetermined limit value.

A disadvantage of previous known devices is that they only give some of the parameters from vehicles in front. The result is too simple a model of a vehicle's surroundings, and the scope for the vehicle's control systems becomes limited. Equipping the vehicle with sensors in the form of cameras, lasers and/or radar makes it possible, however, to extract more information from the vehicle's surroundings. However, extracting information about the behaviour of vehicles in front entails a novel type of processing of the information received from the sensors, as described in more detail in the detailed part of the description below. The invention is particularly suited to estimating the behaviour of vehicles in front travelling in the same direction as the vehicle which is provided with the device according to the invention.

Brief description of drawings

Figure 1 depicts a vehicle (100) according to the present invention as seen from above.

5   Figure 2 shows how information from a vehicle in front (105) travelling in the same direction as the vehicle (100) is gathered by a sensor element (101) at a time $t=t_1$. Figure 3 shows how information from a vehicle in front (105), which in this case is skidding, is gathered by the sensor element (101) at a time $t=t_2$.

Figure 4 depicts a method according to the present invention.

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Detailed description of preferred embodiments of the invention

The invention is described in more detail below with reference to Figures 1-4.

Figure 1 depicts schematically a vehicle (100) as seen from above. The vehicle

15   (100) has at least one sensor element (101) fastened to its forward portion. The sensor element (101) may be one or more in number, in the form of cameras, lasers and/or radar. The sensor element (101) gathers data (102) from a surrounding region (103), here illustrated as a triangular sector in front of the vehicle (100), and sends them, preferably via lines, to a calculation unit (104) which does processing of

20   incoming data (102) , e.g. by filtering and interpolation. The region in front (103) may comprise one or more objects (105) or none at all. The object in front (105) may be a vehicle, but other types of objects, e.g. cargo shed by a vehicle in front, or a moving human being in the region in front, may also be detected.

25   **Figure 2** depicts examples of data which may be gathered at a time $t=t_1$ from a situation illustrated in which the object is a vehicle in front (105) travelling in the same direction as the host vehicle (100). In this case the sensor element (101) and the calculation unit (104) have been able to discern the two rear corners (106,108) of the vehicle in front (105), and vectors (107,109) from the sensor element (101) to the

30   corners (106,108) have been registered. As the calculation unit (104) thus has information about an angle (a) between the vectors (107,109) and the distance to the rear corners (106,108) of the vehicle in front (105), the angle of the vehicle in front (105) relative to the host vehicle (100) may be calculated by the calculation unit

(104) by trigonometric calculations. The sensor element (101) and the calculation unit (104) may also register the cross-sectional area and shape of the rear portion of the vehicle in front (105) in cases where the sensor element (101) takes the form of a laser or camera. This presupposes that with the help of the calculation unit (104)
5   the sensor element (101) registers information from three dimensions, i.e. including in the height direction.

Figure 3 depicts the situation from Figure 2 but at a time $t=t_2$, where $t_2>t_1$ and the vehicle in front (105) is now skidding. The sampling rate for data gathering by the
10   sensor element (101) may be varied. A possible sampling rate is 100 kHz. A higher sampling rate would result in greater accuracy but also require more processor capacity of the calculation unit (104). Here the vectors (107,109) have changed relative to time $t=t_1$, and a new vector (111) has been registered with respect to the forward right corner (110) of the vehicle in front (105). The calculation unit (104) is
15   thus able to calculate relative and absolute positions, speed, acceleration, angle, angular velocity and angular acceleration for the vehicle in front (105). The calculation unit (104) registers that the vehicle in front (105) has suddenly acquired an angular velocity greater than zero while at the same time having a velocity straight ahead, and therefore draws the conclusion that a skid has occurred. The
20   calculation unit (104) can then send a signal to the ESP (electronic stability programme) system and/or other safety systems to prepare for activation.

Examples of other occurrences which the present invention similarly makes it possible to detect from vehicles in front (105) are transverse braking or a sharp
25   swerve to avoid animals or the like. These potentially hazardous situations may also in the same way be registered and generate activation of the safety systems of the vehicle (100).

The limit values which may be used for detection of skidding of the vehicle in front
30   (105) may for example be related to
- angular velocity or angular acceleration relative to the speed of the vehicle in front (105),
- change in the angular acceleration of the vehicle in front (105),

- covariance matrices for the angular acceleration, and/or

- lateral velocity of the vehicle in front (105) relative to its longitudinal velocity. Other more obvious limit values which may be implemented in the device or the method for activation of the vehicle's safety systems according to the present

5   invention might be

- the vehicle in front (105) having a low speed relative to the host vehicle (100), and/or

- the vehicle in front (105) having an opposite speed relative to the host vehicle (100).

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In the situation depicted in Figure 3, the calculation unit (104) may also calculate the cross-sectional area of the right side of the vehicle in front (105) and hence make an approximate estimate of that vehicle's volume when the cross-sectional area of its rear side has already been registered at time $t=t_1$. Information about the weight of

15   the vehicle in front (105) may then be estimated, e.g. by consulting look-up tables or by standard weight per unit volume. As the vehicle in front (105) has in this case skidded and the calculation unit (104) thus has information about its acceleration and estimated weight, it is possible to calculate a friction coefficient for the running surface on which it is travelling. This calculation may involve using Newton's second

20   law which describes the relationship between the resultant force, weight and acceleration of the vehicle in front (105). Newton's second law may be expressed as $F=m^*a$, in which F is the resultant force, m the weight and a the acceleration. This calculation may also be done other way round, i.e. if the vehicle has information about a friction coefficient for the running surface, the weight of the vehicle in front

25   may be estimated when skidding is detected.

Figure 4 depicts a method according to the present invention. As step 1, information is registered from the region (103) in front of the vehicle (100) by means of at least one sensor element (101). The sensor element (101) may be of various different

30   kinds, e.g. it may be a laser situated in the forward portion of the vehicle (100). It may also take the form of radar and/or cameras.

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As step 2, these data (102) are passed on to a calculation unit (104) which may for example take the form of a microprocessor of a known kind.

As step 3, the calculation unit (104) calculates parameters pertaining to one or more vehicles in front (105). The parameters may be one or more from among relative and absolute positions, speed, acceleration, angle, angular velocity and angular acceleration of the vehicle in front (105). A friction coefficient for the running surface on which it is travelling may also be calculated by first estimating its volume and weight and then calculating its acceleration as described above in relation to Figure 3.

As step 4, an output signal containing the calculated parameters about the vehicle in front (105) is sent to the safety system of the vehicle (100) when any of the parameters exceeds a predetermined limit value. For example, information about detected skidding of a vehicle in front (105) may be sent to the ESP system for activation.

If the sensor element (101) is a camera with image processing, various different logics may be implemented in the calculation unit (104). A conceivable function is to detect skidding of the vehicle in front (105) if the camera and the calculation unit (104) register its brake lamp lighting up without any appreciable brake action being registered. Another way of detecting skidding of the vehicle in front (105) is if it has rotated through a certain angle but still has a speed vector in the same direction of movement as the host vehicle (100), this detection also being possible if the sensor element (101) is in the form of radar or laser.

A vehicle (100) according to the present invention may further be equipped with other communication equipment for disseminating the calculated information to other vehicles, alarm centres or the like.

Absolute speed of the vehicle in front (105) means its velocity relative to a fixed point, e.g. the running surface on which it is travelling. Relative speed means the relative velocity between the vehicle in front (105) observed and the host vehicle

(100). As the calculation unit (104) also has information about the parameters of the host vehicle (100), it can convert a measured relative speed to an absolute speed, and so on. Similar reasoning applies to the position, acceleration, angle, angular velocity and angular acceleration of the vehicle in front (105). For example, relative

5 angular velocity may be regarded as more relevant than the absolute angular velocity on bends, since both vehicles (100, 105) will already have a given angular velocity when negotiating a bend.

The above description is primarily intended to facilitate understanding of the

10 invention and is of course not restricted to the embodiments indicated, since other variants of it are also possible and conceivable within the scope of the inventive concept and the protective scope of the claims set out below.

Claims

1. A device pertaining to a vehicle (100) for estimating parameters relating to objects within a region (103) in front of the vehicle (100), which device comprises at least one sensor element (101) fastened to the vehicle (100) to gather data (102) from said region in front (103) and send them to a calculation unit (104) which has a signal connection to a safety system situated in the vehicle (100), **characterised** in that the calculation unit (104) is adapted to calculating at least one of the parameters of angular velocity and angular acceleration for an object within the region (103) and to sending an output signal based on that calculation to one or more safety systems of the vehicle (100) when any of the parameters exceeds a predetermined limit value.

2. A device according to claim 1, **characterised** in that the object is a vehicle in front (105).

3. A device according to claim 2, **characterised** in that one or more of the safety systems of the vehicle (100) are activated upon detection of skidding of the vehicle in front (105).

4. A device according to claim 2 or 3, **characterised** in that one or more of the safety systems of the vehicle (100) are activated upon detection of evasive action by the vehicle in front (105).

5. A device according to any one of claims 2-4, **characterised** in that the calculation unit (104) is adapted to estimating a friction coefficient between the vehicle in front (105) and the carriageway upon detection of skidding of that vehicle.

6. A device according to any one of claims 2-5, **characterised** in that said sensor element (101) is a camera and that the calculation unit (104) detects the occurrence of skidding of the vehicle in front (105) if the camera registers its brake lamp lighting up without any brake action by the vehicle being registered by the calculation unit (104).

7. A method pertaining to a vehicle (100) for estimating parameters relating to objects in front, which method comprises the steps of

- registering data (102) by means of at least one sensor element (101) from a region (103) in front of the vehicle (100),

5   - conveying these data (102) to a calculation unit (104),

characterised by the further steps of

- calculating at least one of the parameters of angular velocity and angular acceleration for an object within the region (103),

- sending an output signal containing the calculated parameters to one or more

10   safety systems of the vehicle (100) when any of the parameters exceeds a predetermined limit value.

8. A method according to claim 7, **characterised** in that the object is a vehicle in front (105).

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9. A method according to claim 8, **characterised** by the further step of

- activating one or more of the safety systems of the vehicle (100) upon detection of skidding of the vehicle in front (105).

20   10. A method according to claim 8 or 9, **characterised** by the further step of

- one or more of the safety systems of the vehicle (100) being activated upon detection of evasive action by the vehicle in front (105).

11. A method according to any one of claims 8-10, **characterised** by the further
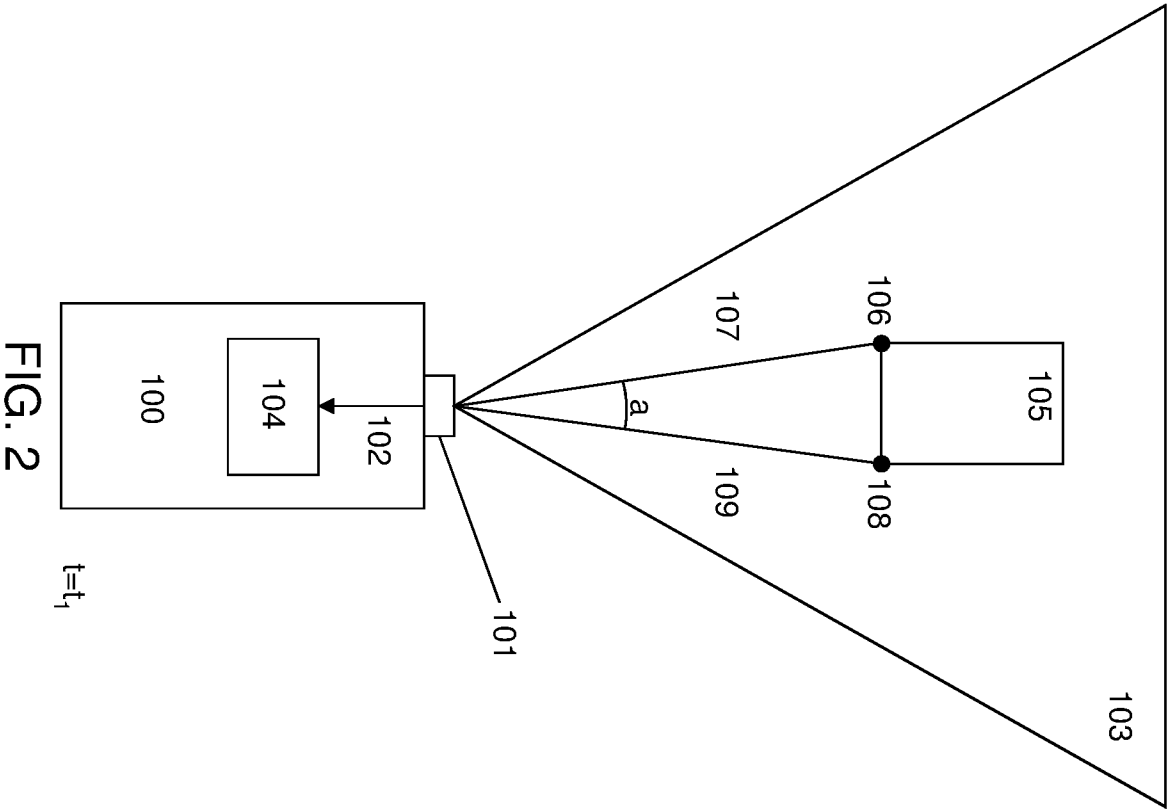
25   step of

- the calculation unit (104) estimating a friction coefficient between the vehicle in front (105) and the carriageway upon detection of skidding of that vehicle.

12. A method according to any one of claims 8-11, in which said sensor element
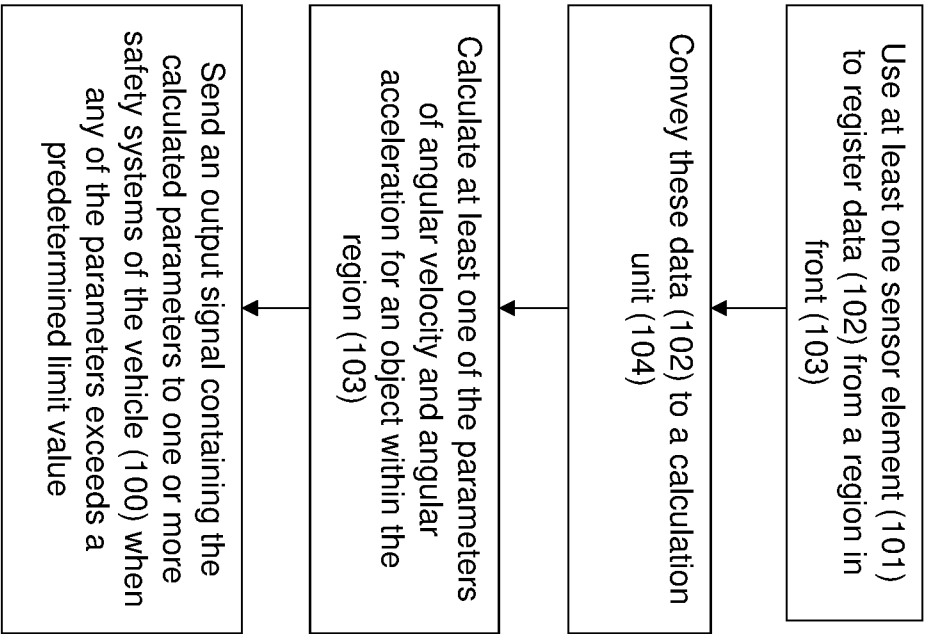
30   (101) is a camera, **characterised** by the further step of

- the calculation unit (104) detecting the occurrence of skidding of the vehicle in front (105) if the camera registers its brake lamp lighting up without any brake action by the vehicle being registered by the calculation unit (104).

FIG. 1

FIG. 2

2/2

FIG. 3

$t=t_2$

FIG. 4

Use at least one sensor element (101) to register data (102) from a region in front (103)

Convey these data (102) to a calculation unit (104)

Calculate at least one of the parameters of angular velocity and angular acceleration for an object within the region (103)

Send an output signal containing the calculated parameters to one or more safety systems of the vehicle (100) when any of the parameters exceeds a predetermined limit value
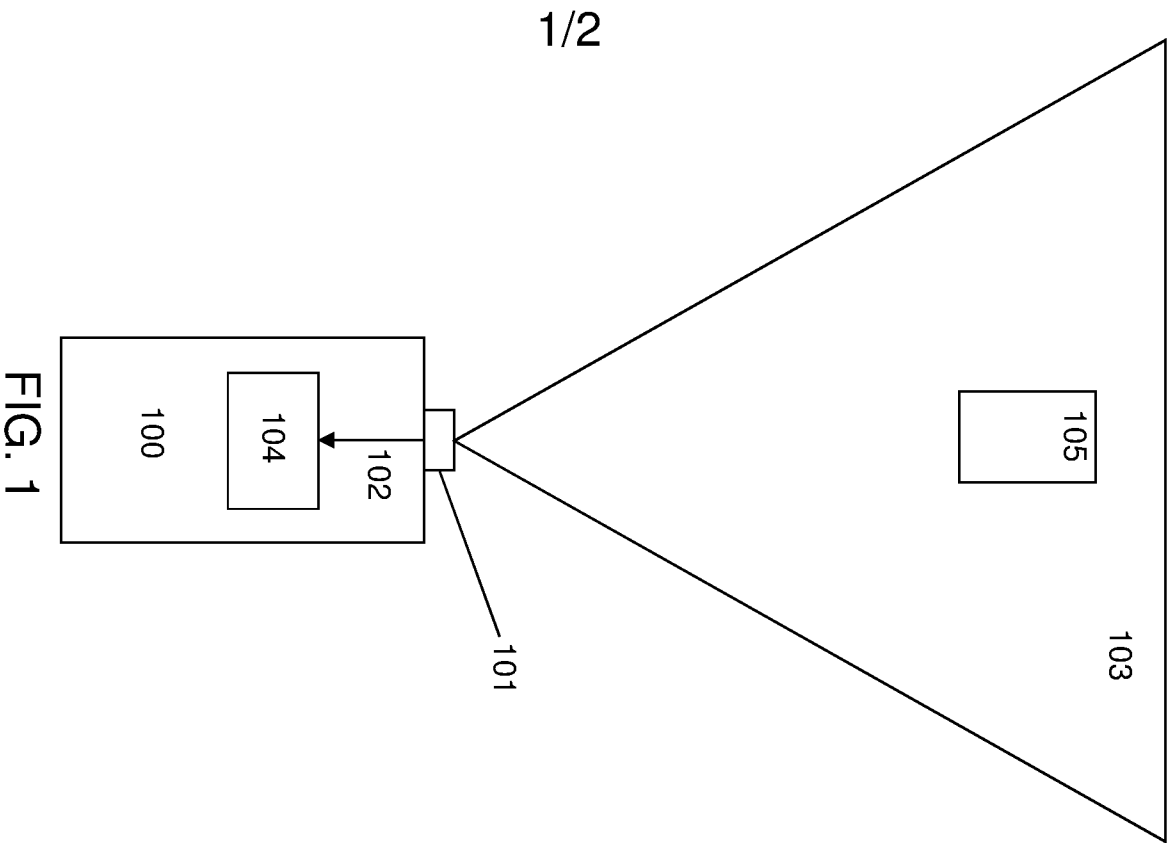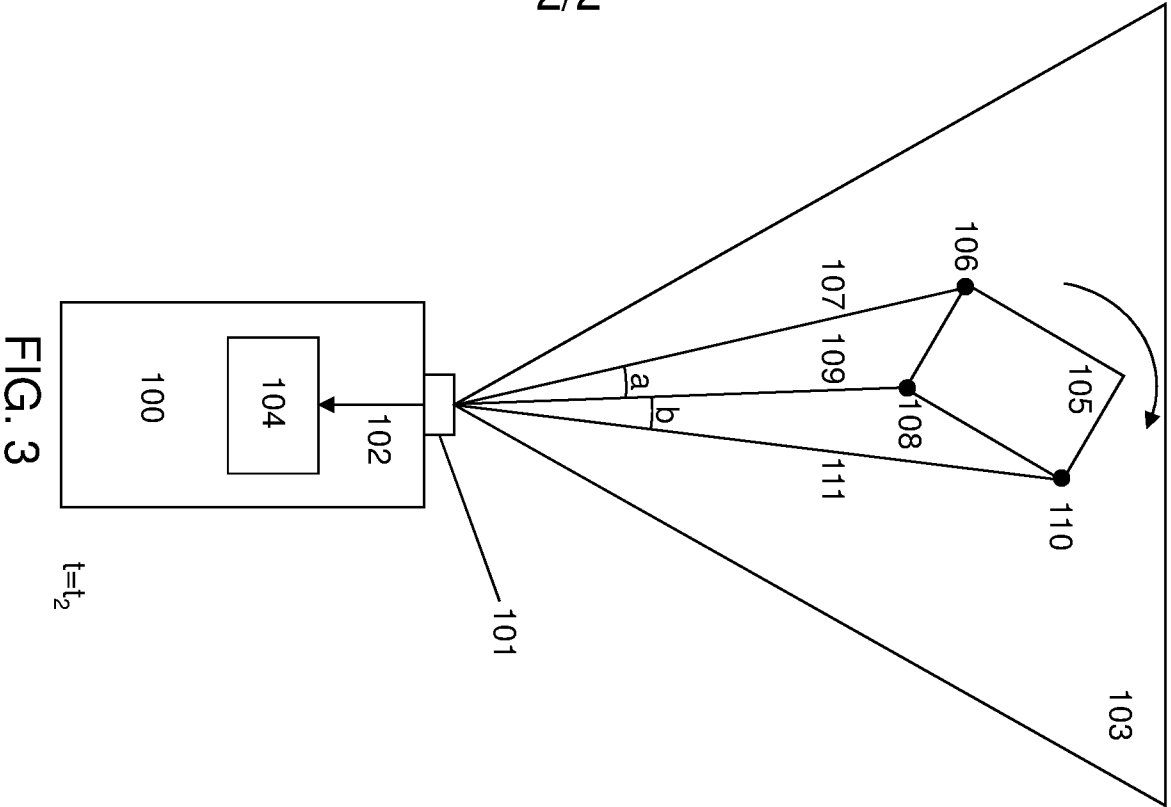
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: B60W, G01S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20030156015 A1 (WINNER HERMANN ET AL), 21 August 2003 (2003-08-21); abstract; paragraph [0037]; figures 1,2 --	1-12
X	US 20090040095 A1 (OGAWA TAKASHI), 12 February 2009 (2009-02-12); paragraph [0200]; figures 1,4 --	1-12
A	US 7365769 B1 (MAGER DONALD), 29 April 2008 (2008-04-29); abstract --	1-12
A	US 6311123 B1 (NAKAMURA MITSURU ET AL), 30 October 2001 (2001-10-30); abstract --	1-12

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
21-06-2012	21-06-2012

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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 6691018 B1 (MIYAHARA SHUNJI), 10 February 2004 (2004-02-10); abstract; figures 1,3 -- --------	1-12

Continuation of: second sheet

International Patent Classification (IPC)

G01S 13/93 (2006.01)
B60W 30/08 (2012.01)
B60W 40/10 (2012.01)

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Cited literature, if any, will be enclosed in paper form.

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