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REGULATION AND/OR CONTROL SYSTEM FOR AN AGRICULTURAL MACHINE

Description

The invention relates to a closed-loop and/or open-loop control system for an agricultural machine having the features of the preamble of claim 1. The invention further relates to an agricultural machine with such a system and to a method for operating an agricultural machine. A closed-loop and/or open-loop control system of the type mentioned at the outset is known, for example, from WO 2015/025015 A1.

In agricultural machines comprising a distributor boom for spreading material, such as fertilizers, plant protection products or seeds, which are designed, for example, as field sprayers, there is a need for the distributor boom to be guided as parallel as possible to the ground or to the plant stock in order to uniformly spread the material. Interference variables that result from relative movements of the machine in relation to the distributor boom and the resulting forces are included in the control. Previous boom guide systems were designed for a passive decoupling of the distributor boom from the machine movements with spring and damper systems. A slow adaptation of the boom inclination to the terrain contour was achieved via active actuating elements.

WO 2015/025015 A1 forms a development of this prior art and describes a boom guide for an agricultural machine, in which the parallel orientation of the boom relative to the ground or a plant surface is achieved by an autonomous control. For this purpose, the distributor boom has several ultrasonic sensors which continuously measure the distance between the boom and the ground. On the basis of these distance signals, position-controlled guidance of the two pivotably-movable cantilever arms of the machine is achieved. In this case, the problem exists that slim obstacles, such as rods, are not detected by the autonomous distance control. Therefore, WO 2015/025015 A1 provides a manual control, which enables a temporary pivoting of the cantilever arms. When the manual control is activated, the autonomous control is interrupted until the intervention by the manual control is completed. The system then returns to autonomous control.

In manual control, a target position for at least one of the two pivotably-movable cantilever arms in relation to the ground surface is specified in a manually-controlled manner. In the known boom guide, the manual control is restricted to the adjustment of a pivot arm.

The object of the invention is to provide a closed-loop and/or open-loop control system for an agricultural machine, in which reliable and precise intervention in the automatic closed-loop control of the distributor boom is possible. The invention is further based upon the object of specifying an agricultural machine with such a system, and a method for operating an agricultural machine.

With regard to the closed-loop and/or open-loop control system, the object is achieved by the subject matter of claim 1. With regard to the agricultural machine, the object is achieved by the subject matter of claim 15. With regard to the method, the object is achieved by the subject matter of independent claim 16.

The invention is based on the provision of a closed-loop and/or open-loop control system for an agricultural machine, which has a distributor boom for spreading material, such as fertilizers, plant protection products or seeds, which boom is pivotable about an axis of rotation which is arranged centrally relative to the distributor boom and extends in the direction of travel.

The closed-loop and/or open-loop control system has at least one sensor device for determining the distance between the ground and/or plant and the distributor boom. The system further comprises a data processing device for processing the sensor signals. The data processing device is configured for an automatic mode and for an override mode, in particular a manual override mode, in each case for adjusting the height and/or inclination of the distributor boom. In the automatic mode, the data processing device adjusts the overall height and/or overall inclination of the distributor boom. For this purpose, the distributor boom is pivoted about the axis of rotation arranged centrally in relation to the distributor boom and extending in the direction of travel, or the distributor boom is raised or lowered vertically overall, i.e., over the entire length.

In the override mode, the data processing device overrides at least one control parameter of the automatic mode, in particular by a manual input. Override means that the automatic mode is active in the override mode or remains active when the override mode is added to the automatic mode. In other words, a control parameter of the automatic mode is purposely changed in the override mode in order to give the user of the machine a possibility of intervening in the automatic control, for example for avoiding collisions.

The override is preferably a manual override, i.e., an override which is at least triggered by a manual input of a user. The manual override can also include the adjustment of the control behavior by the user. The automatic mode is the control during normal operation of the machine.

By means of the override with active automatic mode, it is achieved that the active decoupling of the movements of the distributor boom from the movements of the machine is maintained even if an intervention, in particular a manual intervention, in the automatic control takes place. It is thus possible to respond to a driving situation, for example, which cannot be managed or not adequately managed in the automatic mode, without the automatic control of the distributor boom and thus the decoupling being abandoned. A precise and thus secure intervention in the automatic control is thus possible.

Alternatively, the invention according to independent claim 15 relates to a closed-loop and/or open-loop control system for an agricultural machine, comprising a distributor boom for spreading material, such as fertilizers, plant protection products or seeds, comprising at least one sensor device for determining the distance between the ground and/or plant and the distributor boom and a data processing device for processing the sensor signals, wherein the data processing device is configured for an automatic mode and an override mode, in particular a manual override mode, in each case for adjusting the height and/or inclination of the distributor boom.

The system has at least one sensor device for determining the angular speed of the distributor boom. Additionally or alternatively, the system has a sensor device for determining the translational vertical speed of the distributor boom. According

to the invention, the height and/or inclination of the distributor boom is/are adjusted, at least in the override mode of the data processing device, on the basis of the angular speed of the distributor boom and/or on the basis of the translational vertical speed of the distributor boom.

The closed-loop and/or open-loop control system thus comprises either at least one sensor device for determining the angular speed of the distributor boom or a sensor device for determining the translational vertical speed of the distributor boom. It is also possible for the closed-loop or open-loop control system according to the invention to have at least one sensor device for determining the angular speed of the distributor boom and a sensor device for determining the translational vertical speed of the distributor boom. The angular speed or vertical speed can also be determined by means of linear and/or rotational acceleration sensors, preferably by temporal integration of the corresponding signal.

The sensor device for determining the angular speed of the distributor boom and/or the sensor device for determining the translational vertical speed of the distributor boom can be used in both the automatic mode and the override mode.

With the aid of the sensor device for determining the angular speed of the distributor boom, the inclination of the distributor boom is adjusted on the basis of the angular speed in the override mode of the data processing device. By means of the sensor device for determining the translational vertical speed of the distributor boom, the height adjustment of the distributor boom takes place in the override mode of the data processing device on the basis of the translational vertical speed of the distributor boom.

The advantage of the invention according to independent claim 15 is that the closed-loop control can be overridden independently of the particular ground profile. In other words, the invention offers the possibility of adjusting the distributor boom in the override mode of the data processing device in such a way that the distance between the distributor boom and the ground or the plant cover does not influence the override. The override therefore takes place more precisely, and is thus more reliable than in the prior art.

For this purpose, control is not based solely on the signals of the distance sensors, as in the prior art. Rather, either the angular speed of the distributor boom and/or the translational vertical speed of the distributor boom, i.e., the linear speed of the distributor boom in the vertical direction, is used for manual open-loop control. It is also possible to use the two values, i.e., angular speed and vertical speed, collectively for the open-loop control.

The use of the angular speed and/or the vertical speed opens up various possibilities for individually adapting the manual override, for example by changing the angular speed or vertical speed.

This does not rule out the fact that ground distance signals are also used for the manual override in addition to the angular speed and/or vertical speed.

It is further disclosed that the closed-loop or open-loop control system has at least one sensor device for determining the angle between the machine and the distributor boom and/or a sensor device for determining the vertical distance between the machine and the distributor boom. The height and/or inclination adjustment of the distributor boom takes place, at least in the override mode of the data processing device, on the basis of the angle between the machine and the distributor boom and/or on the basis of the vertical distance between the machine and the distributor boom.

As in the system according to independent claim 15, the disclosed system provides the prerequisite for the manual override to be carried out independently of the distance between the distributor boom and the ground or the stock. For this purpose, it is provided that the angle between the machine and the distributor boom be detected and, accordingly, the adjustment of the inclination of the distributor boom in the manual override mode be carried out on the basis of this angle. Additionally or alternatively, the distance between the machine and the distributor boom is detected in the height direction, i.e., the vertical distance, so that the manual override can take place on the basis of the vertical distance between the machine and the distributor boom. Here too, the intervention in the automatic control for adjusting the position of

the distributor boom takes place more precisely and more reliably than in the prior art, in which the particular ground profile has an influence.

In addition to the angle between the machine and the distributor boom or the vertical distance between the machine and the distributor boom, distance signals relating to the position of the distributor boom relative to the ground or the plant stock can be used.

The systems described above can each be combined with the system according to claim 1, as explained in more detail in connection with the preferred embodiments.

Preferred embodiments of the invention are specified in the dependent claims.

Preferably, at least two different control parameters are provided in the automatic mode. One of the two control parameters is overridden in the override mode. This has the advantage that the other control parameter is not affected by the override or is available unchanged for automatic control. More than two control parameters are possible.

Further preferably, the system has at least one sensor device for determining the angular speed of the distributor boom and/or a sensor device for determining the translational vertical speed of the distributor boom, wherein the height and/or inclination of the distributor boom is/are adjusted, at least in the override mode of the data processing device, on the basis of the angular speed of the distributor boom and/or on the basis of the translational vertical speed of the distributor boom. The angular speed or vertical speed can also be determined by means of linear and/or rotational acceleration sensors, preferably by temporal integration of the corresponding signal.

The data processing device can change a setpoint of the angle between the distributor boom and the ground surface or plant surface in the automatic mode by a predetermined angular speed of the distributor boom when the override mode is activated. The angle setpoint specified in the automatic mode is therefore changed in the override mode at a specific speed, i.e., at a specific angular speed, for example by 0.1° per second. In this embodiment, the ground profile or the profile of the plant

surface does in fact enter into the control. However, the open-loop control does not only take into account the ground distance or plant distance but instead is performed on the basis of a predetermined angular speed, which in turn is individually adjustable so that the precision of the open-loop control in collision avoidance is improved.

In the override mode, the data processing device can change a setpoint of the distance between the distributor boom and the ground or plant surface by a predetermined translational vertical speed of the distributor boom. The same applies here as in connection with the angle change by a predetermined angular speed in the preceding exemplary embodiment. Here too, the precision of the override is improved. A combination of the setpoint change by the angular speed or by the vertical speed is possible so that a combined inclination and height adjustment of the distributor boom is created.

In a further exemplary embodiment, the data processing device sets, in the override mode, a setpoint of the angular speed to a value that is different from zero. In contrast to the setpoint of the control in the automatic mode, which is set to zero to avoid boom movements, a targeted inclination adjustment of the distributor boom is desired in the manual override mode. For this purpose, the setpoint of the angular speed is set to a value that is different from zero and is therefore greater or less than zero. In this embodiment, manual override takes place independently of the ground conditions. Setting the setpoint of the angular speed gives the operator the possibility of flexibly responding to different situations.

In a further embodiment, in the manual override mode, the data processing device sets a setpoint of the translational vertical speed to a value that is different from zero, which is therefore greater or less than zero. This embodiment also allows manual override, independently of the ground profile or the plant cover. The manual inclination override and the manual height override of the aforementioned exemplary embodiments can be used separately or in combination.

After deactivation of the manual override mode, the data processing device can switch into the automatic mode. This ends the manual override mode. This can be done, for example, by an operator of the system keeping a manual input

device, such as a soft key on the input terminal, pressed down in the manual override mode. As soon as the manual input device is no longer pressed, manual override mode ends, and the system automatically returns to automatic mode.

In a further exemplary embodiment of the invention, the data processing device has at least two closed control loops, a second closed control loop of which in particular is a slower form of closed-loop control than a first closed control loop. A setpoint of the second control loop can be set in the override mode. The embodiment has the advantage that all control parameters remain active in the automatic mode when an override takes place. Short-term changes in position of the distributor boom are caused by the first control loop, which operates faster than the second control loop. Comparatively rapid changes in position of the machine, e.g., due to unevenness of the ground, are thus compensated for by the first control loop and are accordingly not transferred to the boom. The second control loop, which is superimposed on the first control loop, is used, due to its slower control compared to the first control loop, to enable an intervention by the operator in the control by means of a manual override.

In this case, the first control loop can have the sensor device for determining the angular speed of the distributor boom. The second control loop can have a sensor device for determining the angle between the machine and the distributor boom and/or a sensor device for determining the vertical distance between the machine and the distributor boom. This creates the prerequisite that the override be carried out independently of the particular ground profile or of the stock.

The first control loop can use a setpoint of the angular speed that corresponds to zero. The first control loop thus operates in automatic mode. The second control loop can use a mean value of the angle between the machine and the distributor boom and/or a mean value of the vertical distance between the machine and the distributor boom, which value is different from zero. The second control loop is thus used for the manual override mode.

Preferably, the sensor device for determining the ground and/or plant distance, in particular ultrasonic sensors, is active in the override mode, for example for additional collision avoidance.

In a further preferred embodiment, the data processing device has different override modes that can be selected. The operator is thus granted even greater flexibility to respond to collision situations by selecting the particular manual override mode suitable for the particular situation.

The invention further claims an agricultural machine for spreading material, such as fertilizers, plant protection products or seeds, comprising a distributor boom and a closed-loop and/or open-loop control system according to any one of the preceding claims. The agricultural machine can be a pulled, a self-propelled, or a carried machine. In a particularly preferred embodiment, the machine is designed as a field sprayer.

In the method according to the invention for operating an agricultural machine comprising a distributor boom and a closed-loop and/or open-loop control system, material, such as fertilizers, plant protection products or seeds, is passed from a storage container and through the distributor boom, wherein the overall height and/or overall inclination of the distributor boom is adjusted in the automatic mode and at least one closed-loop control parameter of the automatic mode is overridden, in particular is manually overridden, in the override mode. The automatic mode is active in override mode.

The automatic mode is the control during normal operation of the machine.

Further disclosed is a method for operating an agricultural machine, which method allows for the adjustment of the height and/or inclination of the distributor boom in both an automatic mode and an override mode. In the override mode, the inclination is adjusted on the basis of the angular speed of the distributor boom. Additionally or alternatively, in the override mode, the height of the distributor boom is adjusted on the basis of the translational vertical speed of the distributor boom. As in the closed-loop or open-loop control system according to claim 15, the method provides the prerequisite for the manual override being carried out independently of the particular ground profile or of the plant cover.

Alternatively, the method can be configured such that, in the override mode, the inclination of the distributor boom is adjusted on the basis of the angle between the machine and the distributor boom. Additionally or alternatively, the height of the distributor boom can be adjusted in the override mode on the basis of the vertical distance between the machine and the distributor boom.

The invention is explained in more detail below with reference to the accompanying schematic drawings.

In the drawings:

Fig. 1 is a rear view of an agricultural machine with a closed-loop and open-loop control system according to an exemplary embodiment according to the invention;

Fig. 2 shows a flowchart of a closed-loop inclination control process according to a first exemplary embodiment according to the invention;

Fig. 3 shows a flowchart of a closed-loop inclination control process according to a second exemplary embodiment according to the invention; and

Fig. 4 shows a flowchart of an inclination control according to a third exemplary embodiment according to the invention.

Fig. 1 schematically shows a rear view of an agricultural machine 2, which is designed as a field sprayer. The machine can be pulled by a towing vehicle, be self-propelled, or be attached to a vehicle. The machine has a distributor boom 3, which is connected to a storage container 5 for supplying the material to be spread. The material may in particular be plant protection products, seeds or fertilizers. For this purpose, the distributor boom 3 has, in a known manner, nozzles which are arranged distributed on the underside of the distributor boom 3. The nozzles are connected by a hose system, likewise known, to a pump and to the storage container 5.

The distributor boom 3 is suspended centrally on the frame of the machine and can be pivoted about an axis of rotation pointing in the direction of travel. This enables an adjustment of the overall inclination of the distributor boom 3, i.e., an adjustment of the folded-out, straight distributor boom 3.

Alternatively, the distributor boom 3 can have a central part which is arranged in a rotationally-fixed manner and on which a cantilever arm is pivotably articulated in each case. An example of this is described in WO 2015/025015 A1. In this case, the two pivot arms are each pivotable about a central axis of the vehicle that points parallel to the direction of travel. This embodiment is possible but not exclusive if, for example, the invention is specifically implemented according to independent claim 15.

In addition, the distributor boom can alternatively be suspended rotatably about an axis which substantially points in the direction of travel, and additionally have two cantilever arms which can be individually angled via actuating elements.

Moreover, the distributor boom 3 is height-adjustable. For this purpose, the distributor boom can be fastened to a vertically-movable lifting frame. Alternatively, a parallelogram boom can be provided in order to adjust the height position.

Hydraulic systems or other actuating systems are suitable as actuators for the inclination and height adjustment.

The invention is not limited to a specific mechanism for adjusting the inclination or adjusting the height of the distributor boom.

The machine according to Fig. 1 has sensor devices for detecting the distance between the distributor boom 3 and the ground, or the distributor boom 3 and the plant cover. The sensor devices for distance measurement can be ultrasonic sensors, for example. Other sensors for distance measurement are possible. In the example according to Fig. 1, two distance sensors 4 are provided for measuring the left and right heights hl, hr of the distributor boom 3 in relation to the ground. Specifically, these are the ultrasonic sensors already mentioned above. Other distance sensors are possible.

A further sensor device detects the angular speed of the distributor boom during a rotational movement about the central axis or axis of rotation extending in the direction of travel. Specifically, the sensor device for detecting the angular speed is designed as an angular speed sensor 6. For a centrally suspended distributor boom 3, a single angular speed sensor which measures the angular speed

during a rotational movement of the distributor boom 3 may be sufficient. In a distributor boom according to WO 2015/025015 A1 comprising a central part designed for conjoint rotation and pivotable boom arms, a separate angular speed sensor is expediently assigned to each boom arm.

The agricultural machine 2 has a closed-loop and open-loop control system (not shown). The system comprises a data processing device for processing the sensor signals from the sensor device for determining the distance between the ground and/or plant and the distributor boom, and at least one further sensor device, for example a sensor device for determining the angular speed of the distributor boom. The data processing device is configured for an automatic mode and an override mode, in particular a manual override mode, which enable a height and/or inclination adjustment of the distributor boom (3) in each case.

If the distributor boom 3 can be pivoted overall about a central axis of rotation or can, overall, be raised/lowered, the data processing device, in the automatic mode, can adjust the total height and/or total inclination of the distributor boom and, in the override mode, override, in particular manually override, at least one control parameter of the automatic mode. The automatic mode is active in the override mode.

The data processing device can be a known job computer or corresponding software, which is configured accordingly.

As described with reference to Figs. 2-4 in conjunction with various exemplary embodiments, the data processing device enables the operation of the machine in an automatic mode and a manual override mode. The manual override mode serves for overriding in order to give the operator the possibility of intervening in the automatic control of the machine in special situations, in particular for avoiding collisions.

Exemplary embodiments 1-3 are each based on the inclination adjustment of the distributor boom 3 in the manual override mode taking place on the basis of the angular speed of the distributor boom 3. The angular speed can enter into the manual open-loop control in different ways, as explained with reference to Examples 1-3. In

addition, exemplary embodiments 1-3 enable manual intervention in the automatic control without the need for the automatic mode to be interrupted for this purpose.

The control according to the automatic mode is accordingly performed in the exemplary embodiments according to Figs. 2-4 and is described in more detail only in connection with the exemplary embodiment according to Fig. 2. The explanations in connection with Fig. 2 also apply to the systems or flowcharts according to Figs. 3 and 4.

The invention is not limited to the flowcharts described in Figs. 2-4 concerning the automatic mode. The automatic control of the height and inclination adjustment of the distributor boom 3 can take place in different ways.

In addition, for the sake of simplicity, only a rotation of the boom in one direction is assumed in the examples according to Figs. 2-4. In the case of a rotation in both directions, the signs change accordingly.

As shown in Fig. 2, when the automatic mode is activated, “automatic mode on," a detection of the left and right distance hL, hR between the distributor boom 3 and the ground (detection of distance hL, hR) takes place. The current angle between the ground surface and the distributor boom 3 is calculated from the distance signals. The current angle enters into the automatic control as an actual value, which is compared in a known manner with an angle setpoint. In automatic mode, the angle setpoint is equal to zero. The distributor boom 3 is to be guided parallel to the ground.

If no manual override takes place, and the angle setpoint is equal to zero, then the distributor boom 3 is adjusted accordingly in order to achieve the angle setpoint between the terrain or ground and the distributor boom. For this purpose, a suitable inclination actuator, e.g., a hydraulic cylinder, is actuated. The automatic closed-loop control according to Fig. 2-4, specifically the closed-loop control according to Fig. 2, comprises a further closed-loop control parameter, specifically the angular speed, which is detected for this purpose (detection of boom angular speed). The angular speed setpoint is set to 0°/s [degrees/second] in the course of the automatic closed-loop control. Accordingly, in the automatic mode, the

distributor boom 3 is controlled in a closed-loop manner on the one hand to the angle setpoint and on the other to the setpoint of the angular speed.

Essentially, the same automatic control is also included in the exemplary embodiments according to Figs. 3 and 4.

For the manual override according to Fig. 2, after the calculation of the current angle between the surface and the boom, it is queried whether either a manual input for adjusting the inclination of the distributor boom 3 (soft key) has taken place, or whether the current angle setpoint is not equal to zero. If the manual inclination adjustment has been actuated, the angle setpoint of the automatic closed-loop control is changed by a predetermined angular speed. In the example according to Fig. 2, the angle setpoint is raised by 0.1°/s [degrees/second]. In this respect, the inclination adjustment takes place in the manual override mode, i.e., during the manual override, on the basis of the angular speed, which is used to change the angle setpoint. This defines the speed at which the distributor boom 3 is moved in order to achieve the corresponding angle setpoint. By determining the angular speed in the manual override mode, the operator can influence the intensity of the response, i.e., the speed of the inclination adjustment. The signal for adjusting the inclination actuator or, generally, the signal for adjusting the inclination of the distributor boom 3 is derived from the differentiated angle setpoint.

If the query “manual inclination adjustment soft key actuated or current angle setpoint not equal to zero” shows that the current angle setpoint is not equal to zero, it is changed to 0 degrees. In this case, too, the angle setpoint is changed on the basis of a predetermined angular speed, for example by 0.1°/s [degrees/second] (lowering the angle setpoint by 0.1 degrees/second to a maximum of 0 degrees). Derived therefrom is again a differentiated angle setpoint, which leads to the signal for actuating the inclination actuator.

Instead of changing the angle setpoint, a distance setpoint can be changed on the basis of a translational vertical speed of the distributor boom 3. A corresponding speed sensor is provided for this purpose. The height position of the distributor boom can thus be set manually in an analogous manner. The

control otherwise takes place accordingly, as in Fig. 2. The height and inclination control can take place separately and in combination.

In summary, in the example according to Fig. 2, the setpoint specification of the distance to the target surface, e.g., of the ground or of the stock, which is detected by distance sensors, e.g., ultrasonic sensors, in the boom, is changed continuously at a predetermined speed when a manual input device, e.g., a soft key, is actuated, until the desired boom position is reached, and the user deactivates the manual input device. In the process, however, only one position of the inclination and/or the height of the distributor boom 3 relative to the ground contour is possible.

In the exemplary embodiment according to Fig. 3, the inclination adjustment or height adjustment is carried out in the manual override mode, relatively, between the distributor boom 3 and the machine 2. The automatic control of the exemplary embodiment according to Fig. 3 takes place according to the automatic control according to Fig. 2. When the manual inclination adjustment is actuated, the setpoint of the angular speed of the distributor boom 3 is set to a value that is different from zero, i.e., to a value that is greater or less than zero. In the example according to Fig. 3, the setpoint of the angular speed is set to a value of 0.001°/s [degrees/second]. Other predetermined setpoints are possible. The distributor boom 3 is pivoted by a corresponding actuation of the inclination actuator in order to achieve the predetermined angular speed. The distance measurement by the sensor device for detecting the distance between the distributor boom and the ground / plant cover is deactivated or used only for a collision query. This means that, in the manual override mode, closed-loop control is performed only at the value of the angular speed sensor or the sensor device for detecting the angular speed. In this respect, the automatic control remains active, in particular partially active.

As can be seen in Fig. 3, in the automatic mode for actively decoupling the distributor boom 3 from the machine, the angular speed of the distributor boom 3 is controlled to zero in a closed-loop manner. In the manual override mode, this target value is raised or lowered by a specific factor by actuating the manual input device so that the setpoint of the angular speed is not equal to zero. As a result, the distributor boom 3 rotates in a predetermined direction.

The exemplary embodiment according to Fig. 3 has the advantage that the inclination of the distributor boom 3 relative to the machine 2 takes place independently of the ground contour. The manual override can be used not only for collision avoidance but also as an emergency function if, for example, the distance sensors fail.

The exemplary embodiment according to Fig. 4 enables a particularly effective superimposition of the automatic mode and the manual override mode so that they can be operated simultaneously. The automatic mode runs as in the exemplary embodiments according to Fig. 2 and 3, wherein both the two distances hL and hR and the angular speed of the distributor boom 3 are detected. In the automatic mode, both the angle setpoint between the distributor boom 3 and the terrain equals zero, and the setpoint of the angular speed of the distributor boom equals zero. In the exemplary embodiment according to Fig. 4, the automatic mode is shown as a first control loop on which a second control loop can be superimposed. The second control loop is used for manual override and is slower than the first control loop. In the flowchart according to Fig. 4, the query is made as to whether the manual input device is actuated ("manual inclination adjustment soft key actuated?"). If this is the case, an inertially-filtered angle value is detected between the distributor boom 3 and the machine 2, or this already detected angle value is taken into account in the manual override. This can be a mean value of the angle between the distributor boom 3 and the machine 2 over a specific period of time. The inertially-filtered angle value is then changed, i.e., increased or lowered, by a predetermined angular speed, e.g., by 0.1 degrees/second, in the course of the manual override. In the example according to Fig. 4, this angle value is increased. The resulting angle setpoint between the distributor boom and the machine 2 is used to actuate the inclination actuator and thus to manually adjust the distributor boom 3.

In other words, the angle between the machine 2 and the distributor boom 3 is thus used as a reference value in order to achieve, on the basis thereof, an adjustment of the inclination of the distributor boom by a specific angular speed. However, since this angle value always changes in order to decouple the distributor boom 3 from the machine movements, the angle between the distributor boom 3 and the machine 2 enters into a superimposed slow control (second control loop) in the exemplary

embodiment according to Fig. 4. In the inner closed control loop (first closed control loop), the angular speed sensor is used as in the examples according to Fig. 2 and 3. This decouples the distributor boom 3 from the machine movements, specifying a boom angular speed of 0°/s [degrees/second]. At the same time, the current angle between the machine 2 and the boom 3 is detected, for example by means of a potentiometer. A mean value is formed therefrom, which is to assume a specific value over a relatively long time, which value is adjusted by the user. In this exemplary embodiment too, as in the exemplary embodiment according to Fig. 3, the manual inclination adjustment of the distributor boom 3 relative to the machine is largely independent of the ground contour.

In the automatic mode, boom movements are actively decoupled from the machine movements by inclination actuators, such as hydraulic inclination cylinders. The angular speed of the boom = 0. The inclination cylinder moves continuously and decouples the distributor boom 3 from the machine 2. The distributor boom 3 is aligned with distance sensors parallel to the ground / plant stock.

In the override mode, boom movements are still actively decoupled from the machine movements by the inclination actuators, such as hydraulic inclination cylinders. The angular speed of the boom is ≈ 0. The inclination cylinder moves continuously. The control unit or data processing device adjusts the boom, based upon user inputs, to the inertially-filtered angle value relative to the machine.

In contrast thereto, in the case of an exclusively manual mode, the boom would be rigidly connected to the machine. Each movement of the machine would be transferred directly to the boom. The inclination cylinder could only be moved to the left or right in a defined manner via the control unit in order to rotate the boom, and would otherwise be rigid.

The manual override of the height control, which is not shown in Fig. 4, takes place in an analogous manner. Here too, the height between the boom and the machine, i.e., the distance between the boom and the machine, is detected over a longer period of time. The mean value formed therefrom is used in the control, i.e., the mean value enters into the control. The decoupling of the machine

movements then takes place, as in the case of the inclination adjustment, via a rapidly-responding pressure control of the hydraulic pressure in the cylinders.

PATENTKRAV

1. Regulerings- og/eller styresystem til en landbrugsmaskine (2), der omfatter en fordelerbom (3) til udspredning af materiale, såsom gødningsstoffer, plantebeskyttelsesmidler eller såsæd, hvilket styresystem kan dreje omkring en rotationsakse, der er anbragt centralt i forhold til fordelerbommen (3) og strækker sig i køreretningen, med mindst én sensorindretning til bestemmelse af jordafstanden og/eller planteafstanden fra fordelerbommen (3) og en databehandlingsindretning til behandling af sensorsignalerne, hvor databehandlingsindretningen er konfigureret til en automatikmodus, i hvert tilfælde til indstilling af fordelerbommens (3) højde og/eller hældning, **kendetegnet ved, at** databehandlingsindretningen er konfigureret til en overstyringsmodus, især en manuel overstyringsmodus, i hvert tilfælde til indstilling af fordelerbommens (3) højde og/eller hældning, hvor databehandlingsindretningen indstiller fordelerbommens (3) samlede højde og/eller samlede hældning i automatikmodussen og overstyrer, især overstyrer den manuelt, mindst én styreparameter for automatikmodussen i overstyringsmodussen, idet automatikmodussen er aktiv i overstyringsmodussen.

2. System ifølge krav 1, **kendetegnet ved, at** der i automatikmodussen er tilvejebragt mindst to forskellige styreparametre, hvoraf én styreparameter overstyres i overstyringsmodussen.

3. System ifølge krav 1 eller krav 2, **kendetegnet ved** mindst én sensorindretning til bestemmelse af fordelerbommens (3) vinkelhastighed og/eller en sensorindretning til bestemmelse af fordelerbommens (3) translatoriske vertikalhastighed, hvor fordelerbommens (3) højde og/eller hældning mindst i databehandlingsindretningens overstyringsmodus indstilles på basis af fordelerbommens (3) vinkelhastighed og/eller på basis af fordelerbommens (3) translatoriske vertikalhastighed.

4. System ifølge et hvilket som helst af de foregående krav, især ifølge krav 3, **kendetegnet ved, at** databehandlingsindretningen i automatikmodussen, ved aktivering af overstyringsmodussen, ændrer en referenceværdi for vinklen mellem

fordelerbommen (3) og jord- eller planteoverfladen med en forudbestemt vinkelhastighed for fordelerbommen (3).

5. System ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** databehandlingsindretningen i overstyringsmodussen ændrer en referenceværdi for afstanden mellem fordelerbommen (3) og jord- eller planteoverfladen med en forudbestemt translatorisk vertikalhastighed for fordelerbommen (3).

6. System ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** databehandlingsindretningen i overstyringsmodussen fastsætter en referenceværdi for vinkelhastigheden til en værdi, der er forskellig fra nul.

7. System ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** databehandlingsindretningen i overstyringsmodussen fastsætter en referenceværdi for den translatoriske vertikalhastighed til en værdi, der er forskellig fra nul.

8. System ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** databehandlingsindretningen skifter til automatikmodussen efter deaktivering af overstyringsmodussen.

9. System ifølge et hvilket som helst af de foregående krav, især ifølge et hvilket som helst af kravene 3 til 5, **kendetegnet ved, at** databehandlingsindretningen har mindst to styrekredsløb, hvor det er muligt at fastsætte en referenceværdi for det andet styrekredsløb i overstyringsmodussen.

10. System ifølge krav 9, **kendetegnet ved, at** det andet styrekredsløb er en langsommere form for styring end det første styrekredsløb.

11. System ifølge krav 9 eller 10, **kendetegnet ved, at** det første styrekredsløb har en sensorindretning til bestemmelse af fordelerbommens (3) vinkelhastighed, og det andet styrekredsløb har en sensorindretning til bestemmelse af vinklen mellem maskinen (2) og fordelerbommen (3) og/eller en sensorindretning til bestemmelse af den vertikale afstand mellem maskinen (2) og fordelerbommen (3).

12. System ifølge krav 11, **kendetegnet ved, at** der i det første styrekredsløb anvendes en referenceværdi for vinkelhastigheden, der svarer til nul, og der i det andet styrekredsløb anvendes en middelværdi for vinklen mellem maskinen (2) og fordelerbommen (3) og/eller en middelværdi for den vertikale afstand mellem maskinen (2) og fordelerbommen (3), der er forskellig fra nul.

13. System ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** sensorindretningen til bestemmelse af jord- og/eller planteafstanden, især ultralydssensorer, er aktiv/aktive i overstyringsmodussen.

14. System ifølge et hvilket som helst af de foregående krav, **kendetegnet ved, at** databehandlingsindretningen har forskellige overstyringsmodi, der kan vælges.

15. Landbrugsmaskine til udspredning af materiale, såsom gødningsstoffer, plantebeskyttelsesmidler eller såsæd, hvilken landbrugsmaskine omfatter en fordelerbom (3) og et regulerings- og/eller styresystem ifølge et hvilket som helst af de foregående krav.

16. Fremgangsmåde til drift af en landbrugsmaskine (2), der omfatter en fordelerbom (3) og et regulerings- og/eller styresystem ifølge et hvilket som helst af kravene 1 til 14, hvor materiale, såsom gødningsstoffer, plantebeskyttelsesmidler eller såsæd, udspredes fra en opbevaringsbeholder (5) gennem fordelerbommen (3), hvor fordelerbommens samlede højde og/eller samlede hældning indstilles i automatikmodussen, og mindst én styreparameter for automatikmodussen overstyres, især overstyres den manuelt, i overstyringsmodussen, hvor automatikmodussen er aktiv i overstyringsmodussen.

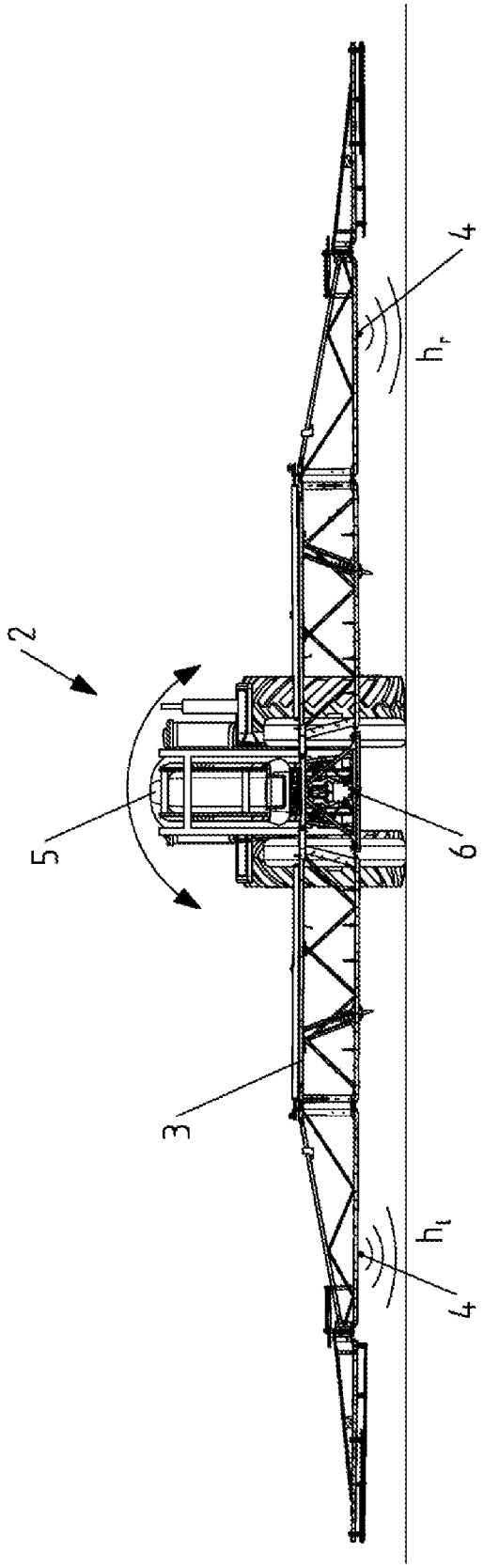

Fig. 1

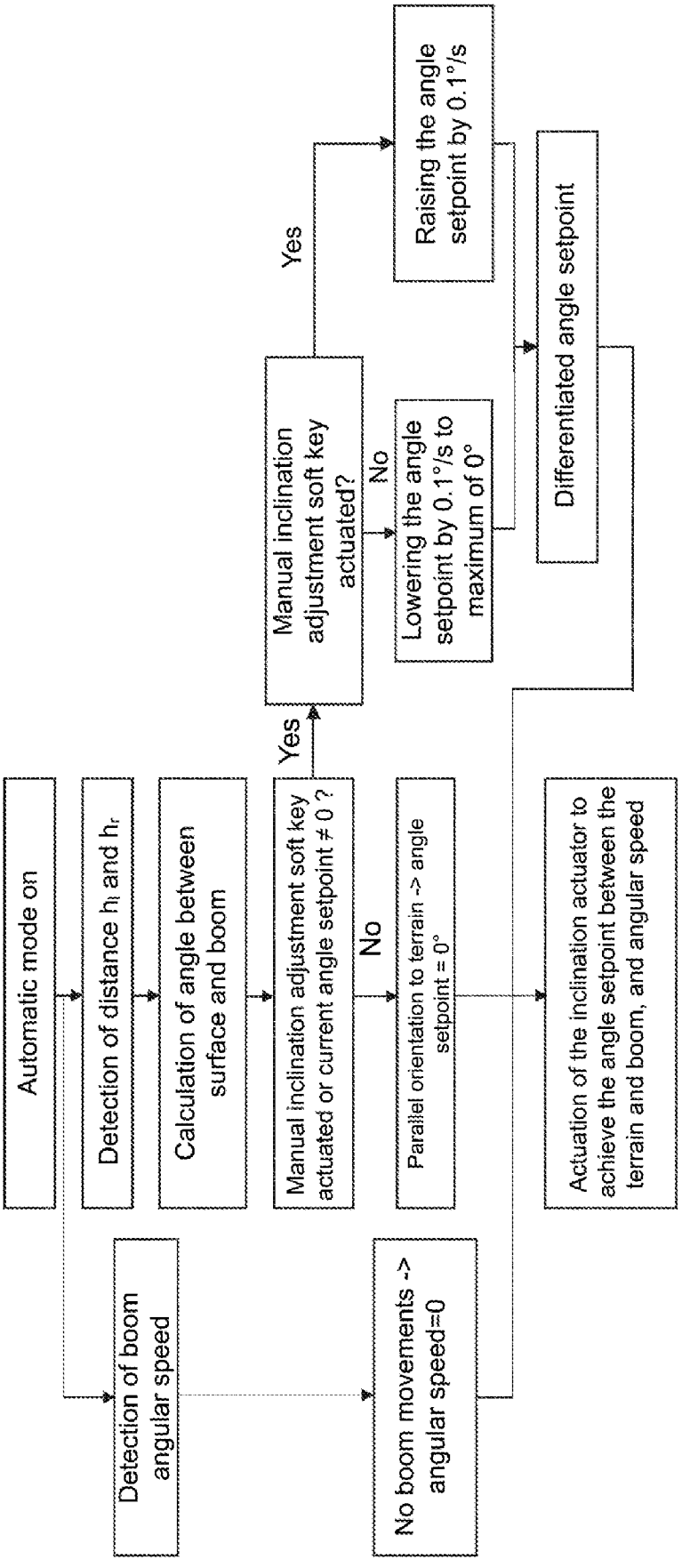
Automatic mode on
Detection of distance h_l and h_r
Calculation of angle between surface and boom
Manual inclination adjustment soft key actuated or current angle setpoint ≠ 0 ?
Yes
No
Manual inclination adjustment soft key actuated?
Yes
No
Raising the angle setpoint by 0.1°/s
Lowering the angle setpoint by 0.1°/s to maximum of 0°
Differentiated angle setpoint
Parallel orientation to terrain -> angle setpoint = 0°
Actuation of the inclination actuator to achieve the angle setpoint between the terrain and boom, and angular speed
Detection of boom angular speed
No boom movements -> angular speed=0

Fig. 2

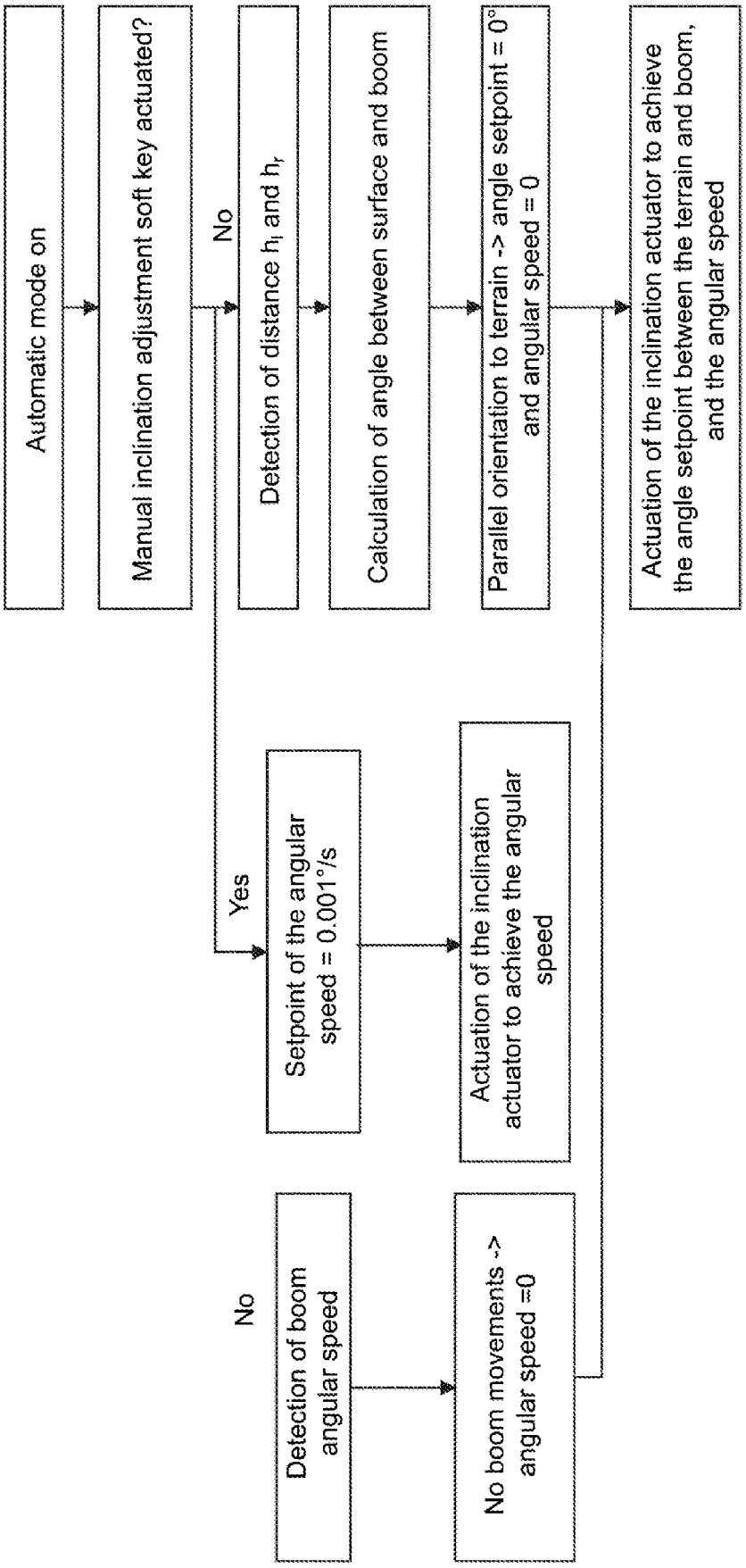
Automatic mode on
Manual inclination adjustment soft key actuated?
No
Detection of distance h_l and h_r
Calculation of angle between surface and boom
Parallel orientation to terrain -> angle setpoint = 0° and angular speed = 0
Actuation of the inclination actuator to achieve the angle setpoint between the terrain and boom, and the angular speed
Yes
Setpoint of the angular speed = 0.001°/s
Actuation of the inclination actuator to achieve the angular speed
No
Detection of boom angular speed
No boom movements -> angular speed =0

Fig. 3

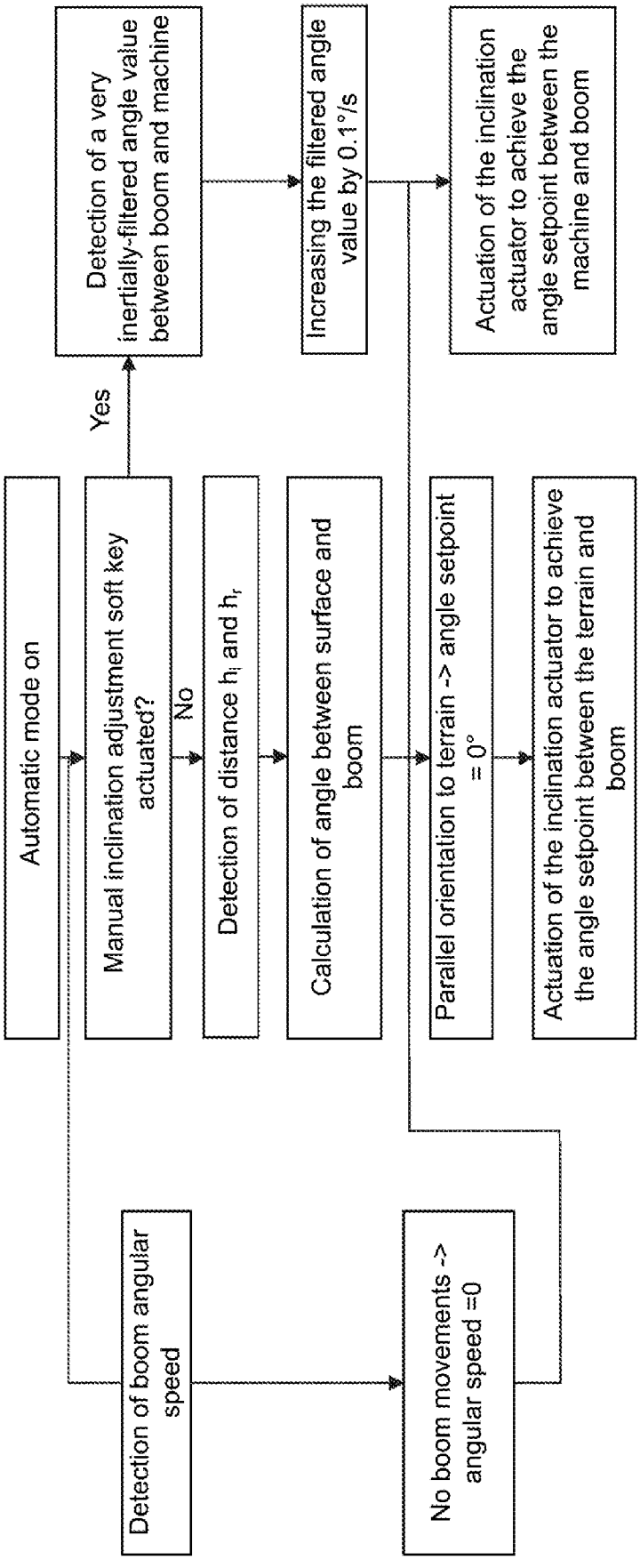
Automatic mode on
Manual inclination adjustment soft key actuated?
Yes
No
Detection of a very inertially-filtered angle value between boom and machine
Increasing the filtered angle value by 0.1°/s
Actuation of the inclination actuator to achieve the angle setpoint between the machine and boom
Detection of distance h_l and h_r
Calculation of angle between surface and boom
Parallel orientation to terrain -> angle setpoint = 0°
Actuation of the inclination actuator to achieve the angle setpoint between the terrain and boom
Detection of boom angular speed
No boom movements -> angular speed =0

Fig. 4