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(54) ENHANCING DRILLING ACCURACY FOR A MOBILE UNDERGROUND DRILLING RIG, AND RELATED DEVICES, METHODS AND COMPUTER PROGRAMS

(57) Apparatuses, methods, computer programs and systems for enhancing drilling accuracy for a mobile underground drilling rig are disclosed. With the disclosed inertial measurement unit (IMU) (11), a vertical orientation error caused by a drilling boom (3) and/or a feed rail (5) bending may be directly measured and corrected, for example. A position error caused by the drilling boom 3 bending may be corrected or at least reduced by using the IMU 11 data in compensation data/models. Such combined/new compensation data does not depend on drilling direction, such as face drilling, ramp drilling, and cross-cut drilling. Furthermore, the IMU (11) may be used to measure a change in a feed angle caused by contact forces between the feed rail (5) and rock, thereby further improving overall mining accuracy.

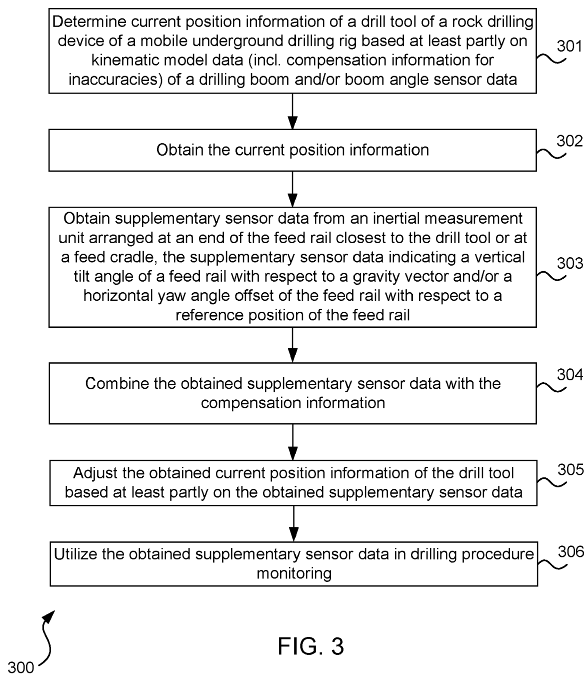

FIG. 3

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to the field of industrial systems, and, more particularly, to enhancing drilling accuracy for a mobile underground drilling rig, as well as related devices, methods and computer programs.

BACKGROUND

[0002] Mobile underground drilling rig work in a challenging environment, such as in an underground mine.

[0003] Rock drilling is typically carried out by using drilling equipment comprising a carrier provided with at least one boom with a rock drilling unit at a distal end of the at least one boom. The rock drilling unit comprises a feeding system configured to keep a drill bit in contact with rock during drilling. The feeding system comprises a feed rail configured to support and guide a rock drilling device that is configured to move along the feed rail during a drilling procedure. As accurate control of the feed rail enables accurate rock drilling, controlling the position of the feed rail plays a role in efficient operation.

SUMMARY

[0004] The scope of protection sought for various example embodiments of the disclosure is set out by the independent claims. The example embodiments and features, if any, described in this specification that do not fall under the scope of the independent claims are to be interpreted as examples useful for understanding various example embodiments of the disclosure.

[0005] An example embodiment of a control apparatus for a mobile underground drilling rig comprises at least one processor, and at least one memory including computer program code. The mobile underground drilling rig comprises a drilling boom and a feed rail configured to move with respect to a feed cradle connected to the drilling boom. The feed rail is further configured to support and guide a rock drilling device arranged to move along the feed rail during a drilling procedure. The at least one memory and the computer program code are configured to, with the at least one processor, cause the control apparatus at least to obtain current position information of a drill tool of the rock drilling device. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the control apparatus at least to obtain supplementary sensor data from an inertial measurement unit arranged at an end of the feed rail closest to the drill tool or at the feed cradle. The supplementary sensor data indicates at least one of a vertical tilt angle, v, of the feed rail with respect to a gravity vector or a horizontal yaw angle, u, offset of the feed rail with respect to a reference position of the feed rail. The at least one memory and the computer program code are further configured to, with the at least one processor, cause the control apparatus at least to adjust the obtained current position information of the drill tool based at least partly on the obtained supplementary sensor data.

[0006] An example embodiment of a control method for a mobile underground drilling rig comprising a drilling boom and a feed rail configured to move with respect to a feed cradle connected to the drilling boom, the feed rail being further configured to support and guide a rock drilling device arranged to move along the feed rail during a drilling procedure, comprises obtaining, at a control apparatus for the mobile underground drilling rig, current position information of a drill tool of the rock drilling device. The control method further comprises obtaining, at the control apparatus, supplementary sensor data from an inertial measurement unit arranged at an end of the feed rail closest to the drill tool or at the feed cradle, the supplementary sensor data indicating at least one of a vertical tilt angle of the feed rail with respect to a gravity vector or a horizontal yaw angle offset of the feed rail with respect to a reference position of the feed rail. The control method further comprises adjusting, by the control apparatus, the obtained current position information of the drill tool based at least partly on the obtained supplementary sensor data.

[0007] An example embodiment of a computer program comprises instructions for causing a control apparatus for a mobile underground drilling rig comprising a drilling boom and a feed rail configured to move with respect to a feed cradle connected to the drilling boom, the feed rail being further configured to support and guide a rock drilling device arranged to move along the feed rail during a drilling procedure, to perform at least the following: obtaining current position information of a drill tool of the rock drilling device; obtaining supplementary sensor data from an inertial measurement unit arranged at an end of the feed rail closest to the drill tool or at the feed cradle, the supplementary sensor data indicating at least one of a vertical tilt angle of the feed rail with respect to a gravity vector or a horizontal yaw angle offset of the feed rail with respect to a reference position of the feed rail; and adjusting the obtained current position information of the drill tool based at least partly on the obtained supplementary sensor data.

[0008] In an example embodiment, alternatively or in addition to the above-described example embodiments, the at least one memory and the computer program code are further configured to, with the at least one processor, cause the control apparatus to determine the current position information of the drill tool based at least partly on at least one of kinematic model data of the drilling boom or boom angle sensor data.

[0009] In an example embodiment, alternatively or in addition to the above-described example embodiments, the kinematic model data of the drilling boom comprises compensation information for inaccuracies.

[0010] In an example embodiment, alternatively or in addition to the above-described example embodiments, the compensation information comprises at least one of first compensation data for a bending of at least one of the drilling boom or the feed rail, second compensation data for a position of the drill tool, or third compensation data for a roll angle of the drill tool.

[0011] In an example embodiment, alternatively or in addition to the above-described example embodiments, the at least one memory and the computer program code are further configured to, with the at least one processor, cause the control apparatus to combine the obtained supplementary sensor data with the compensation information.

[0012] In an example embodiment, alternatively or in addition to the above-described example embodiments, the at least one memory and the computer program code are further configured to, with the at least one processor, cause the control apparatus to utilize the obtained supplementary sensor data in monitoring the drilling procedure.

[0013] An example embodiment of a mobile underground drilling rig comprises a drilling boom. The mobile underground drilling rig further comprises a feed rail configured to move with respect to a feed cradle connected to the drilling boom. The feed rail is further configured to support and guide a rock drilling device arranged to move along the feed rail during a drilling procedure. The mobile underground drilling rig further comprises an inertial measurement unit arranged at an end of the feed rail closest to a drill tool of the rock drilling device or at the feed cradle. The mobile underground drilling rig further comprises the control apparatus according to any of the above-described example embodiments.

[0014] In an example embodiment, alternatively or in addition to the above-described example embodiments, the inertial measurement unit comprises at least one accelerometer and at least one gyroscope.

[0015] In an example embodiment, alternatively or in addition to the above-described example embodiments, the at least one accelerometer comprises at least one accelerometer of at least one axis.

[0016] In an example embodiment, alternatively or in addition to the above-described example embodiments, the at least one gyroscope comprises at least one gyroscope of at least one axis.

[0017] Many of the features will be more readily appreciated as they become better understood by reference to the following detailed description considered in connection with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

[0018] The accompanying drawings, which are included to provide a further understanding of the embodiments and constitute a part of this specification, illustrate embodiments and together with the description help to explain the principles of the embodiments. In the drawings:

FIG. 1 shows an example embodiment of the subject matter described herein illustrating an example mobile underground drilling rig, where various embodiments of the present disclosure may be implemented;

FIG. 2 shows an example embodiment of the subject matter described herein illustrating an example control apparatus for a mobile mining vehicle, where various embodiments of the present disclosure may be implemented;

FIG. 3 shows an example embodiment of the subject matter described herein illustrating a method; and

FIG. 4 shows an example embodiment of the subject matter described herein illustrating a diagram showing a vertical tilt angle and a horizontal yaw angle.

[0019] Like reference numerals are used to designate like parts in the accompanying drawings.

DETAILED DESCRIPTION

[0020] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. The detailed description provided below in connection with the appended drawings is intended as a description of the present examples and is not intended to represent the only forms in which the present example may be constructed or utilized. The description sets forth the functions of the example and the sequence of steps for constructing and operating the example. However, the same or equivalent functions and sequences may be accomplished by different examples.

[0021] Fig. 1 illustrates an example mobile underground drilling rig 1, where various embodiments of the present disclosure may be implemented.

[0022] The mobile underground drilling rig 1 comprises a drilling boom 3. The mobile underground drilling rig 1 further comprises a feed rail 5 configured to move with respect to a feed cradle 10 connected to the drilling boom 3. The feed rail 5 is further configured to support and guide a rock drilling device 6 arranged to move along the feed rail 5 during a drilling procedure.

[0023] The mobile underground drilling rig 1 may further comprise a carrier 2 and a drilling unit 4 associated with the drilling boom 3. The drilling boom 3 may comprise one or more boom angle sensors 3a, 3b, 3c. The drilling boom 3 may further be connected to the drilling unit 4, e.g., by a joint. The drilling unit 4 may comprise the feed rail 5 on which the rock drilling device 6 can be moved. Further, the drilling unit 4 may comprise a drill tool 7 with which impact pulses given by a percussion device of the rock drilling device 6 are transmitted to the rock to be drilled.

[0024] In the example of Fig. 1, the mobile underground drilling rig 1 may further comprise at least one control unit 8 arranged to control actuators of the mobile underground drilling rig 1, for example. The control unit 8 may comprise or be connected to a user interface with a display device 9 as well as operator input interface for receiving operator commands and information to the control unit 8. In some embodiments, the control unit 8 is configured to control at least boom automation control related operations, and there may be one or more other control units in the mobile underground drilling rig 1 for controlling other operations.

[0025] The mobile underground drilling rig 1 further comprises an inertial measurement unit (IMU) 11 that is arranged at an end of the feed rail 5 closest to the drill tool 7 or at the feed cradle 10.

[0026] At least in some embodiments, the IMU 11 may comprise at least one accelerometer and at least one gyroscope. For example, the at least one accelerometer may comprise at least one accelerometer of at least one axis. For example, the at least one gyroscope may comprise at least one gyroscope of at least one axis. At least in some embodiments, the at least one accelerometer may comprise a three-axis accelerometer, and/or the at least one gyroscope may comprise a three-axis gyroscope.

[0027] The three-axis accelerometer may comprise three accelerometers mounted orthogonally, thereby enabling analyzing separate components of acceleration. The three-axis accelerometer may be configured to measure three mutually orthogonal components of acceleration of gravity. The three-axis gyroscope may comprise three orientation sensors, thereby configured to measure rotation around three axes such as pitch, yaw and roll.

[0028] The mobile underground drilling rig 1 further comprises a control apparatus 200. The control apparatus 200 will be described in more detail below in connection with Fig. 2. At least in some embodiments, the control apparatus 200 may be comprised in the control unit 8.

[0029] In the following, various example embodiments will be discussed. At least some of these example embodiments may allow enhancing drilling accuracy for the mobile underground drilling rig 1. Some of the described features are optional features which may provide further advantages.

[0030] Fig. 2 is a block diagram of the control apparatus 200 for the mobile underground drilling rig 1, in accordance with an example embodiment. The apparatus 200 may be, for example, an electronic device such as a module comprised in an automation or control system, a chip or a chipset.

[0031] The control apparatus 200 comprises at least one processor 202, and at least one memory 204 including computer program code. The apparatus 200 may also include other elements not shown in Fig. 2. Furthermore, at least in some embodiments, the apparatus 200 may be included or integrated in the control unit 8.

[0032] Although the apparatus 200 is depicted to include only one processor 202, the apparatus 200 may include more processors. In an embodiment, the memory 204 is capable of storing instructions, such as an operating system and/or various applications. Furthermore, the memory 204 may include a storage that may be used to store, for example, at least some of the information and data used in the disclosed embodiments.

[0033] Furthermore, the processor 202 is capable of executing the stored instructions. In an embodiment, the processor 202 may be embodied as a multi-core processor, a single core processor, or a combination of one or more multi-core processors and one or more single core processors. For example, the processor 202 may be embodied as one or more of various processing devices, such as a coprocessor, a microprocessor, a controller, a digital signal processor (DSP), a processing circuitry with or without an accompanying DSP, or various other processing devices including integrated circuits such as, for example, an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), a microcontroller unit (MCU), a hardware accelerator, a special-purpose computer chip, a neural network chip, an artificial intelligence (AI) accelerator, or the like. In an embodiment, the processor 202 may be configured to execute hard-coded functionality. In an embodiment, the processor 202 is embodied as an executor of software instructions, wherein the instructions may specifically configure the processor 202 to perform the algorithms and/or operations described herein when the instructions are executed.

[0034] The memory 204 may be embodied as one or more volatile memory devices, one or more non-volatile memory devices, and/or a combination of one or more volatile memory devices and non-volatile memory devices. For example, the memory 204 may be embodied as semiconductor memories (such as mask ROM, PROM (programmable ROM), EPROM (erasable PROM), flash ROM, RAM (random access memory), etc.).

[0035] The at least one memory 204 and the computer program code are configured to, with the at least one processor 202, cause the control apparatus 200 at least to obtain current position information of the drill tool 7 of the rock drilling device 6.

[0036] At least in some embodiments, the at least one memory 204 and the computer program code may further be configured to, with the at least one processor 202, cause the control apparatus 200 to determine the current position information of the drill tool 7 based at least partly on kinematic model data of the drilling boom 3 and/or data from the boom angle sensor(s) 3a-3c.

[0037] For example, the kinematic model data may comprise information on physical characteristics of mobile underground drilling rig 1 or components thereof. According to an example embodiment, the kinematic model data may comprise information on physical characteristics of mobile underground drilling rig 1 or components thereof affecting positioning of drill tool 7. For example, the kinematic model data may comprise dimensions and/or reach of mobile underground drilling rig 1 or component (s) thereof, such as dimensions of drilling boom 3 and/or mobile underground drilling rig 1, reach of drilling boom 3, characteristics of the joints (e.g., type of the joints, such as rotational or prismatic), constraints between the moving parts of mobile underground drilling rig 1, or the like.

[0038] At least in some embodiments, a kinematic model of the mobile underground drilling rig 1, or component(s) thereof, may comprise a mathematical description of at least a part of the mobile underground drilling rig 1. The kinematic model may describe a motion of the mobile underground drilling rig 1 or a motion of component(s) of the mobile underground drilling 1 without taking into account the forces that cause the motion. Accordingly, the kinematic model may be used, e.g., to determine a position of a component of the mobile underground drilling rig 1 based on sensor data, such as the data from the boom angle sensor(s) 3a-3c.

[0039] At least in some embodiments, the kinematic model data of the drilling boom 3 may comprise compensation information for inaccuracies caused by, e.g., mechanical bending and/or manufacturing tolerances (e.g., inaccuracies in the position information of the drill tool 7) . In other words, the compensation information may be used to model the inaccuracies caused by the mechanical bending, the manufacturing tolerances, and/or the like. For example, the compensation information may comprise first compensation data for a bending of the drilling boom 3 and/or the feed rail 5, second compensation data for a position (herein, "position" may include "orientation") of the drill tool 7, and/or third compensation data for a roll angle of the drill tool 7.

[0040] Here, "bending" compensation relates to compensation of longitudinal motions of the drilling boom 3 and/or the feed rail 5, "position" compensation relates to compensation of sideward/horizontal/vertical motions of the drilling boom 3 and/or the feed rail 5, and "roll angle or roll-over" compensation relates to compensation of rotating motions of the drilling boom 3 around a drill rod of the rock drilling device 6. Such a bending compensation may be modelled, e.g., with a bending compensation model of drilling boom 3 and/or feed rail 5.

[0041] The at least one memory 204 and the computer program code are further configured to, with the at least one processor 202, cause the control apparatus 200 at least to obtain supplementary sensor data from the IMU 11 arranged at the end of the feed rail 5 closest to the drill tool 7 or at the feed cradle 10. Herein, the "supplementary" in the supplementary sensor data indicates that the supplementary sensor data is for supplementing the obtained current position information of the drill tool 7 of the rock drilling device 6, as described in more detail below. The supplementary sensor data indicates a vertical tilt angle (illustrated as "v" in diagram 400 of Fig. 4) of the feed rail 5 with respect to a gravity vector and/or a horizontal yaw angle (illustrated as "u" in diagram 400 of Fig. 4) offset of the feed rail 5 with respect to a reference position of the feed rail 5.

[0042] At least in some embodiments, the at least one memory 204 and the computer program code may further be configured to, with the at least one processor 202, cause the control apparatus 200 to combine the obtained supplementary sensor data with the compensation information.

[0043] For example, a pre-generated boom bending compensation model may be enhanced by the disclosed supplementary sensor data. At least in some situations, external forces may cause the data in the pre-generated boom bending compensation model (e.g., related to the positioning of drill tool 7) to be erroneous. The disclosed supplementary sensor data may be used to correct and/or detect such errors.

[0044] Alternatively, the disclosed supplementary sensor data may be used to enhance or correct data in a rigid kinematic model of the joints and other components of mobile underground drilling rig 1.

[0045] The at least one memory 204 and the computer program code are further configured to, with the at least one processor 202, cause the control apparatus 200 at least to adjust the obtained current position information of the drill tool 7 based at least partly on the obtained supplementary sensor data.

[0046] For example, the kinematic model data may comprise data on distances between joints of the drilling boom 3, and/or data on angles of the joints of the drilling boom 3. In other words, the kinematic model data may comprise data on dimensions of the drilling boom 3. Accordingly, the kinematic model data may further be used, e.g., in determining/obtaining initial measurements for the position of the drill tool 7. Accuracy of the thus determined/obtained initial measurements may then be improved with the compensation information that may compensate for various possible inaccuracies in the initial measurements. After that, the disclosed supplementary sensor data from the IMU 11 may be used to adjust the initial measurements (e.g., directly or by enhancing/-correcting data in the rigid kinematic model, as discussed above), thereby further enhancing drilling accuracy for the mobile underground drilling rig 1. Furthermore, data from the IMU 11 may be used as input for the compensation information.

[0047] At least in some embodiments, the at least one memory 204 and the computer program code may further be configured to, with the at least one processor 202, cause the control apparatus 200 to utilize the obtained supplementary sensor data in monitoring the drilling procedure. For example, the monitoring may comprise monitoring whether the feed rail 5 loses contact with the rock while drilling.

[0048] Fig. 3 illustrates an example flow chart of a control method 300 for the mobile underground drilling rig 1, in accordance with an example embodiment. In the example of Fig. 3, the method 300 comprises a computer-implemented method.

[0049] At optional operation 301, the control apparatus 200 may determine the current position information of the drill tool 7 of the rock drilling device 6 based at least partly on the kinematic model data of the drilling boom 3 and/or the boom angle sensor 3a-3c data.

[0050] At operation 302, the current position information (which may have been determined previously at operation 301) of the drill tool 7 is obtained at the control apparatus 200.

[0051] At operation 303, the supplementary sensor data from the inertial measurement unit 11 is obtained at the control apparatus 200. As described above, the inertial measurement unit 11 is arranged at the end of the feed rail 5 closest to the drill tool 7 or at the feed cradle 10, and the supplementary sensor data indicates the vertical tilt angle of the feed rail 5 with respect to the gravity vector and/or the horizontal yaw angle offset of the feed rail 5 with respect to the reference position of the feed rail 5.

[0052] As described above, the kinematic model data of the drilling boom 3 may comprise the compensation information for inaccuracies. At optional operation 304, the control apparatus 200 may combine the obtained supplementary sensor data with the compensation information.

[0053] At operation 305, the control apparatus 200 adjusts the obtained current position information of the drill tool 7 based at least partly on the obtained supplementary sensor data.

[0054] At optional operation 306, the control apparatus 200 may utilize the obtained supplementary sensor data in monitoring the drilling procedure.

[0055] The method 300 may be performed by the control apparatus 200 of Fig. 2. The operations 301-306 can, for example, be performed by the at least one processor 202 and the at least one memory 204. Further features of the method 300 directly result from the functionalities and parameters of the control apparatus 200, and thus are not repeated here. The method 300 can be performed by computer program(s).

[0056] The control apparatus 200 may comprise means for performing at least one method described herein. In an example, the means may comprise the at least one processor 202, and the at least one memory 204 including program code configured to, when executed by the at least one processor 202, cause the control apparatus 200 to perform the method.

[0057] At least some of the disclosed example embodiments may allow enhancing drilling accuracy for a mobile underground drilling rig. With the disclosed IMU 11, a vertical orientation error caused by the drilling boom 3 and/or feed rail 5 bending may be directly measured and corrected, for example. A position error caused by the drilling boom 3 bending may be corrected or at least reduced by using the IMU 11 data in the compensation data/models. Such combined/new compensation data does not depend on drilling direction, such as face drilling, ramp drilling, and cross-cut drilling. Furthermore, the IMU 11 may be used to measure a change in a feed angle caused by contact forces between the feed rail 5 and rock, thereby further improving overall mining accuracy. The change in the feed angle may comprise a relative change, and at least in some embodiments, the relative change in the feed angle may be combined with calculated (and possibly compensated) position/angle data.

[0058] The functionality described herein can be performed, at least in part, by one or more computer program product components such as software components. According to an embodiment, the control apparatus 200 may comprise a processor or processor circuitry, such as for example a microcontroller, configured by the program code when executed to execute the embodiments of the operations and functionality described. Alternatively, or in addition, the functionality described herein can be performed, at least in part, by one or more hardware logic components. For example, and without limitation, illustrative types of hardware logic components that can be used include Field-programmable Gate Arrays (FPGAs), Application-specific Integrated Circuits (ASICs), Application-specific Standard Products (ASSPs), System-on-a-chip systems (SOCs), Complex Programmable Logic Devices (CPLDs), and Graphics Processing Units (GPUs).

[0059] Any range or device value given herein may be extended or altered without losing the effect sought. Further, any embodiment may be combined with another embodiment unless explicitly disallowed.

[0060] Although the subject matter has been described in language specific to structural features and/or acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as examples of implementing the claims and other equivalent features and acts are intended to be within the scope of the claims.

[0061] It will be understood that the benefits and advantages described above may relate to one embodiment or may relate to several embodiments. The embodiments are not limited to those that solve any or all of the stated problems or those that have any or all of the stated benefits and advantages. It will further be understood that reference to 'an' item may refer to one or more of those items.

[0062] The steps of the methods described herein may be carried out in any suitable order, or simultaneously where appropriate. Additionally, individual blocks may be deleted from any of the methods without departing from the spirit and scope of the subject matter described herein. Aspects of any of the embodiments described above may be combined with aspects of any of the other embodiments described to form further embodiments without losing the effect sought.

[0063] The term 'comprising' is used herein to mean including the method, blocks or elements identified, but that such blocks or elements do not comprise an exclusive list and a method or apparatus may contain additional blocks or elements.

[0064] It will be understood that the above description is given by way of example only and that various modifications may be made by those skilled in the art. The above specification, examples and data provide a complete description of the structure and use of example embodiments. Although various embodiments have been described above with a certain degree of particularity, or with reference to one or more individual embodiments, those skilled in the art could make numerous alterations to the disclosed embodiments without departing from the scope of this specification.

Claims

1. A control apparatus (200) for a mobile underground drilling rig (1) comprising a drilling boom (3) and a feed rail (5) configured to move with respect to a feed cradle (10) connected to the drilling boom (3), the feed rail (5) being further configured to support and guide a rock drilling device (6) arranged to move along the feed rail (5) during a drilling procedure, the control apparatus (200) comprising:

    at least one processor (202); and
    at least one memory (204) including computer program code;
    the at least one memory (204) and the computer program code configured to, with the at least one processor (202), cause the control apparatus (200) at least to:

        obtain current position information of a drill tool (7) of the rock drilling device (6);
        obtain supplementary sensor data from an inertial measurement unit (11) arranged at an end of the feed rail (5) closest to the drill tool (7) or at the feed cradle (10), the supplementary sensor data indicating at least one of a vertical tilt angle, v, of the feed rail (5) with respect to a gravity vector or a horizontal yaw angle, u, offset of the feed rail (5) with respect to a reference position of the feed rail (5); and
        adjust the obtained current position information of the drill tool (7) based at least partly on the obtained supplementary sensor data.

2. The control apparatus (200) according to claim 1, wherein the at least one memory (204) and the computer program code are further configured to, with the at least one processor (202), cause the control apparatus (200) to determine the current position information of the drill tool (7) based at least partly on at least one of kinematic model data of the drilling boom (3) or boom angle sensor (3a-3c) data.

3. The control apparatus (200) according to claim 2, wherein the kinematic model data of the drilling boom (3) comprises compensation information for inaccuracies.

4. The control apparatus (200) according to claim 3, wherein the compensation information comprises at least one of first compensation data for a bending of at least one of the drilling boom (3) or the feed rail (5), second compensation data for a position of the drill tool (7), or third compensation data for a roll angle of the drill tool (7).

5. The control apparatus (200) according to claim 3 or 4, wherein the at least one memory (204) and the computer program code are further configured to, with the at least one processor (202), cause the control apparatus (200) to combine the obtained supplementary sensor data with the compensation information.

6. The control apparatus (200) according to any of claims 1 to 5, wherein the at least one memory (204) and the computer program code are further configured to, with the at least one processor (202), cause the control apparatus (200) to utilize the obtained supplementary sensor data in monitoring the drilling procedure.

7. A control method (300) for a mobile underground drilling rig (1) comprising a drilling boom (3) and a feed rail (5) configured to move with respect to a feed cradle (10) connected to the drilling boom (3), the feed rail (5) being further configured to support and guide a rock drilling device (6) arranged to move along the feed rail (5) during a drilling procedure, the control method () comprising:

    obtaining (302), at a control apparatus (200) for the mobile underground drilling rig (1), current position information of a drill tool (7) of the rock drilling device (6);
    obtaining (303), at the control apparatus (200), supplementary sensor data from an inertial measurement unit (11) arranged at an end of the feed rail (5) closest to the drill tool (7) or at the feed cradle (10), the supplementary sensor data indicating at least one of a vertical tilt angle of the feed rail (5) with respect to a gravity vector or a horizontal yaw angle offset of the feed rail (5) with respect to a reference position of the feed rail (5); and
    adjusting (305), by the control apparatus (200), the obtained current position information of the drill tool (7) based at least partly on the obtained supplementary sensor data.

8. A computer program comprising instructions for causing a control apparatus for a mobile underground drilling rig comprising a drilling boom and a

feed rail configured to move with respect to a feed cradle connected to the drilling boom, the feed rail being further configured to support and guide a rock drilling device arranged to move along the feed rail during a drilling procedure, to perform at least the following:

obtaining current position information of a drill tool of the rock drilling device;
obtaining supplementary sensor data from an inertial measurement unit arranged at an end of the feed rail closest to the drill tool or at the feed cradle, the supplementary sensor data indicating at least one of a vertical tilt angle of the feed rail with respect to a gravity vector or a horizontal yaw angle offset of the feed rail with respect to a reference position of the feed rail; and
adjusting the obtained current position information of the drill tool based at least partly on the obtained supplementary sensor data.

9. A mobile underground drilling rig (1), comprising:

a drilling boom (3);
a feed rail (5) configured to move with respect to a feed cradle (10) connected to the drilling boom (3), the feed rail (5) being further configured to support and guide a rock drilling device (6) arranged to move along the feed rail (5) during a drilling procedure;
an inertial measurement unit (11) arranged at an end of the feed rail (5) closest to a drill tool (7) of the rock drilling device (6) or at the feed cradle (10); and
the control apparatus (200) according to any of claims 1 to 6.

10. The mobile underground drilling rig (1) according to claim 9, wherein the inertial measurement unit (11) comprises at least one accelerometer and at least one gyroscope.

11. The mobile underground drilling rig (1) according to claim 10, wherein the at least one accelerometer comprises at least one accelerometer of at least one axis.

12. The mobile underground rig (1) according to claim 10 or 11, wherein the at least one gyroscope comprises at least one gyroscope of at least one axis.

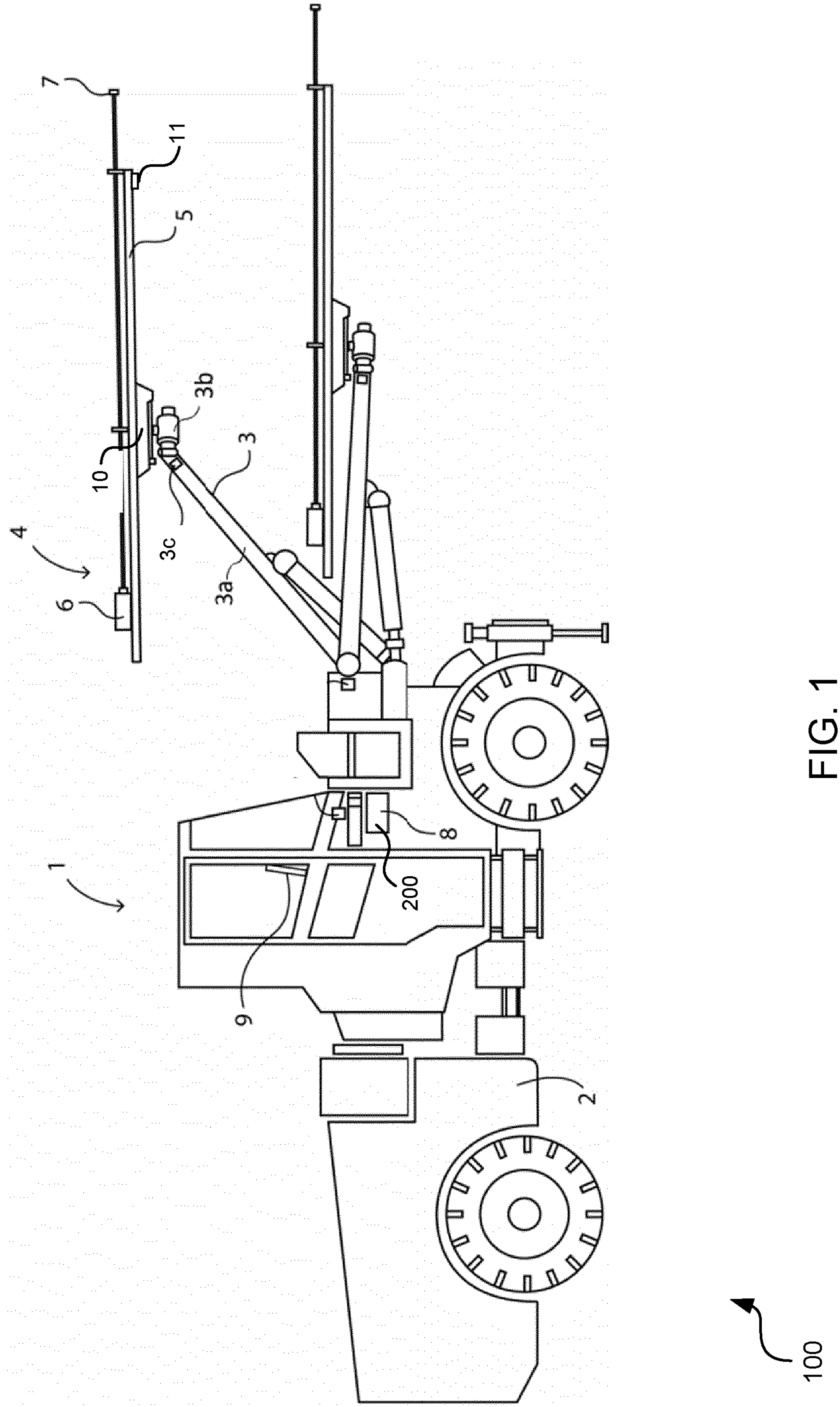

FIG. 1

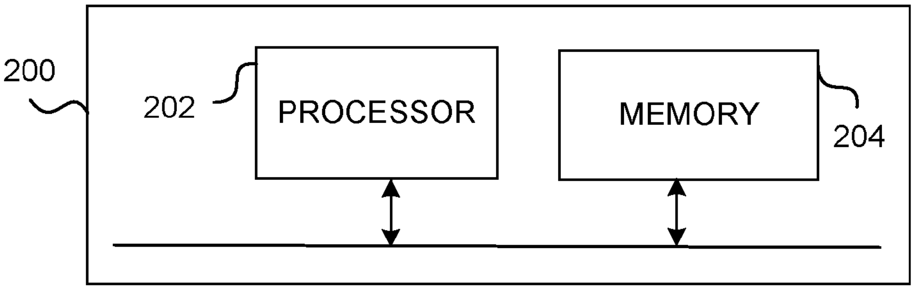
200
202
PROCESSOR
MEMORY
204

FIG. 2

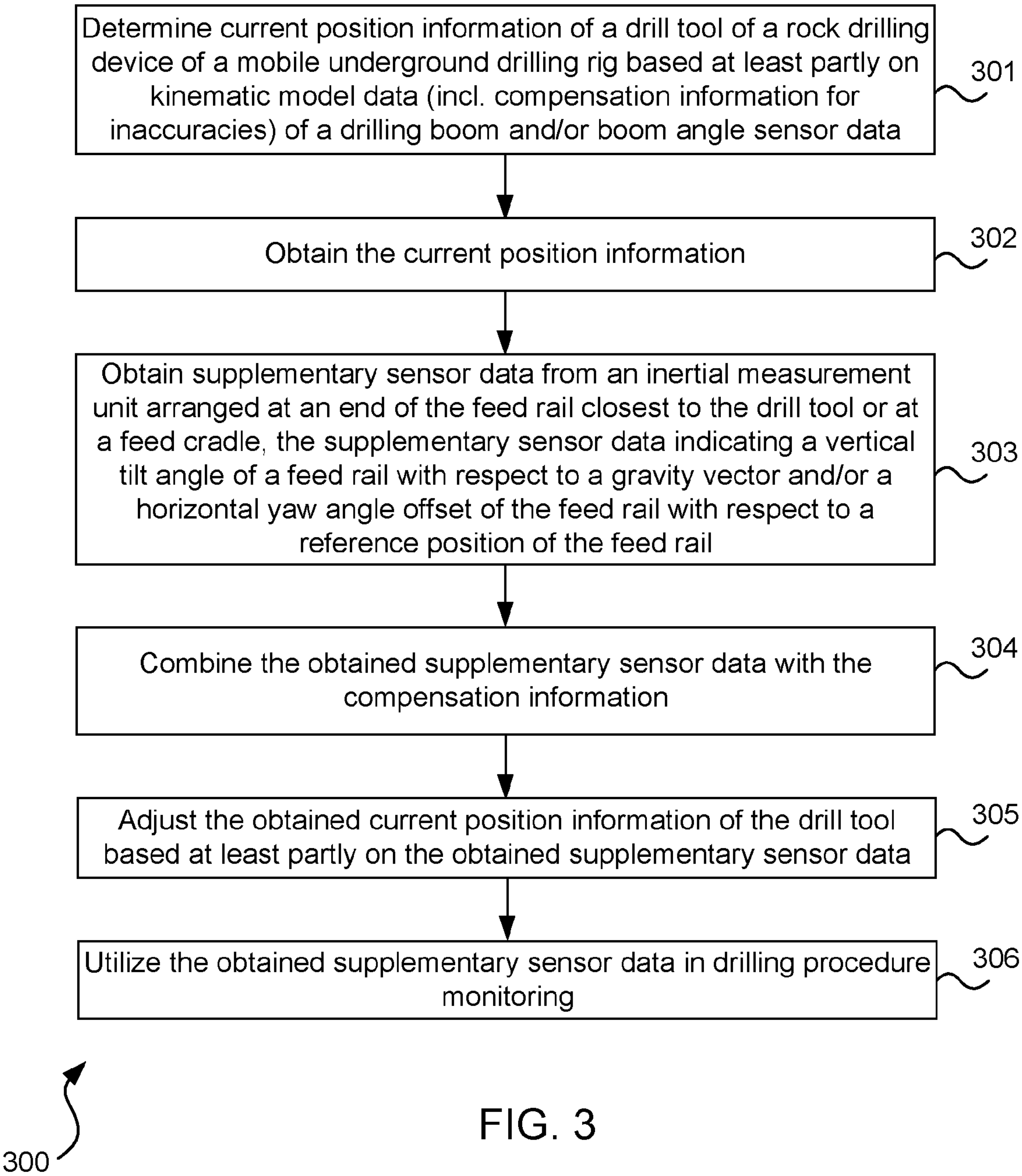
Determine current position information of a drill tool of a rock drilling device of a mobile underground drilling rig based at least partly on kinematic model data (incl. compensation information for inaccuracies) of a drilling boom and/or boom angle sensor data
301
Obtain the current position information
302
Obtain supplementary sensor data from an inertial measurement unit arranged at an end of the feed rail closest to the drill tool or at a feed cradle, the supplementary sensor data indicating a vertical tilt angle of a feed rail with respect to a gravity vector and/or a horizontal yaw angle offset of the feed rail with respect to a reference position of the feed rail
303
Combine the obtained supplementary sensor data with the compensation information
304
Adjust the obtained current position information of the drill tool based at least partly on the obtained supplementary sensor data
305
Utilize the obtained supplementary sensor data in drilling procedure monitoring
306
300

FIG. 3

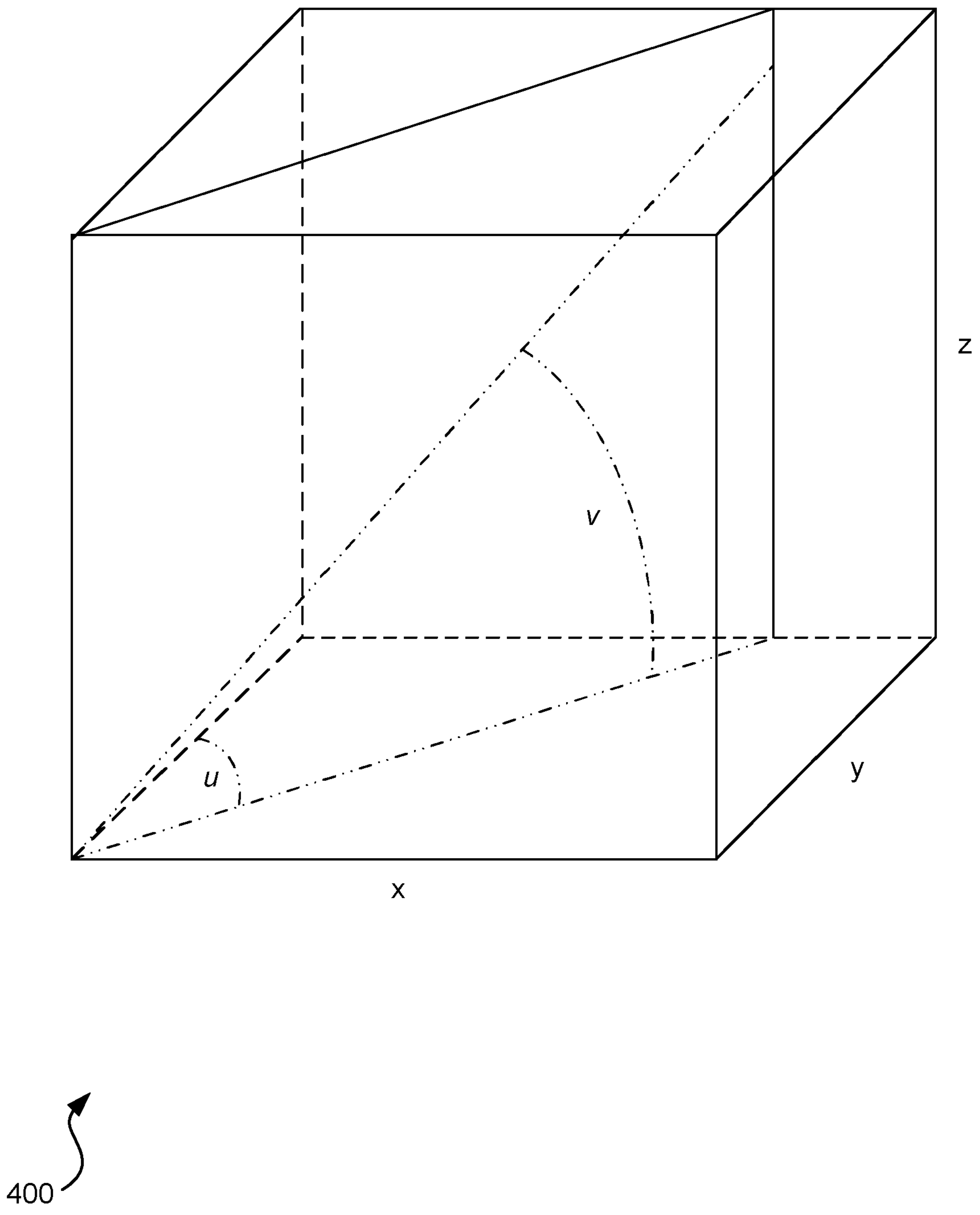

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 6959

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 4 148 231 A1 (SANDVIK MINING & CONSTRUCTION OY [FI]) 15 March 2023 (2023-03-15) * paragraphs [0008], [0015], [0018], [0027], [0028], [0036], [0037], [0040] - [0042], [0046], [0050], [0051], [0055], [0058], [0064], [0067], [0069] - paragraphs [0071], [0073], [0079], [0081], [0084], [0089], [0090]; figure 2 *	1-12	INV. E21B7/02 E21C35/06
A	WO 2022/250674 A1 (VECTOR MAGNETICS LLC [US]) 1 December 2022 (2022-12-01) * paragraphs [0015], [0165]; figures 2,29 *	1-12	

TECHNICAL FIELDS SEARCHED (IPC)

E21B
E21C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 March 2024	Georgescu, Mihnea

CATEGORY OF CITED DOCUMENTS

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12-03-2024

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		EP 4148231 A1	15-03-2023
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