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(54) **CONTROLLING SENSOR(S) OF A DRILL RIG**

(57) Example embodiments relate to sensor control of a drill rig. An apparatus may comprise: at least one processor; and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to: obtain informa-

tion on operational status of the drill rig; determine, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and cause the at least one sensor of the drill rig to transition to the power saving mode.

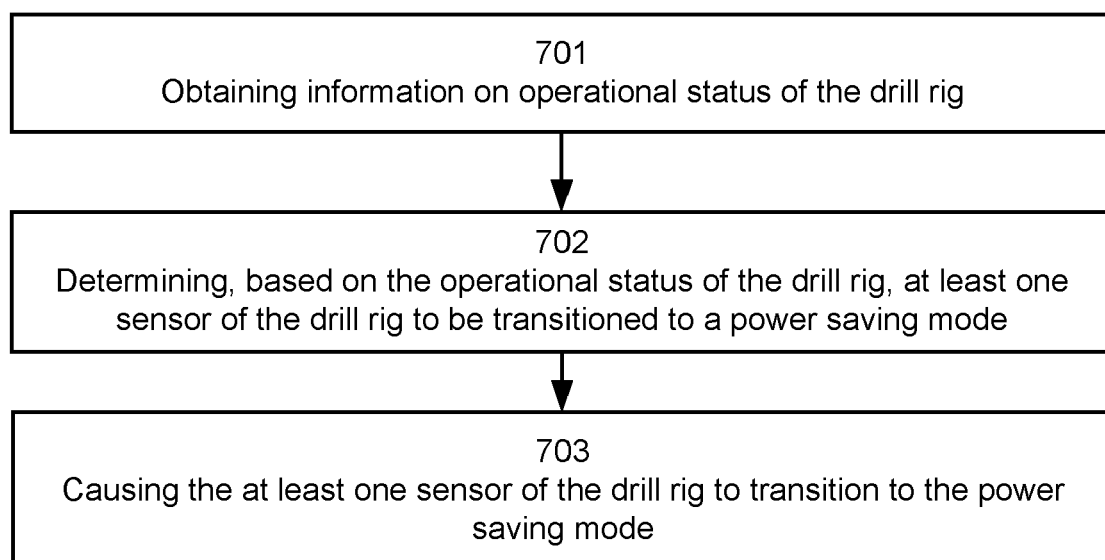


FIG. 7

Description

TECHNICAL FIELD

[0001] Various example embodiments generally relate to the field of controlling drill rigs. Some example embodiments relate to controlling sensor(s) of a drill rig based on operational status of the drill rig.

BACKGROUND

[0002] Drill rigs may be equipped with various sensors in order to monitor operations of the drill rig or environment of the drill rig. Sensors may be distributed at different parts of a drill rig and connected by wires to a common power supply.

SUMMARY

[0003] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

[0004] According to first aspect of the present disclosure, an apparatus for sensor control of a drill rig is disclosed. The apparatus may comprise: at least one processor; and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to: obtain information on operational status of the drill rig; determine, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and cause the at least one sensor of the drill rig to transition to the power saving mode.

[0005] According to another aspect of the present disclosure, a sensor is disclosed. The sensor may comprise the apparatus of the first aspect, and the at least one memory and the computer program may be code configured to, with the at least one processor, cause the apparatus to transition the sensor to the power saving mode based on the operational status of the drill rig.

[0006] According to another aspect of the present disclosure, a method for sensor control of a drill rig is disclosed. The method may comprise: obtaining information on operational status of the drill rig; determining, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and causing the at least one sensor of the drill rig to transition to the power saving mode.

[0007] According to another aspect of the present disclosure, an apparatus is disclosed. The apparatus may comprise: means for obtaining information on operational status of the drill rig; means for determining, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving

mode; and means for causing the at least one sensor of the drill rig to transition to the power saving mode.

[0008] According to another aspect of the present disclosure, a computer program, a computer program product, or a (non-transitory) computer-readable medium is disclosed. The computer program, computer program product, or (non-transitory) computer-readable medium may comprise program instructions which, when executed by an apparatus, cause the apparatus at least to: obtain information on operational status of the drill rig; determine, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and cause the at least one sensor of the drill rig to transition to the power saving mode

[0009] Example embodiments of the above aspects are described in the claims, the description, and/or the drawings. According to some aspects, there is provided the subject matter of the independent claims. Some further aspects are defined in the dependent claims. Many of the attendant features will be more readily appreciated as they become better understood by reference to the following description considered in connection with the accompanying drawings.

LIST OF DRAWINGS

[0010] The accompanying drawings, which are included to provide a further understanding of the example embodiments and constitute a part of this specification, illustrate example embodiments and, together with the description, help to explain the example embodiments. In the drawings:

FIG. 1 illustrates an example of an underground drill rig;

FIG. 2 illustrates an example of a surface drill rig;

FIG. 3 illustrates an example of communication links between a sensor controller, a rig controller, and sensor(s) of a drill rig;

FIG. 4 illustrates an example of signalling and operations for controlling sensor(s) of a drill rig to transition to a power saving mode based on operational status of the drill rig;

FIG. 5 illustrates an example of signalling and operations of a sensor for transitioning to a power saving mode based on operational status of a drill rig; FIG. 6 illustrates an example of an apparatus configured to practise one or more example embodiments;

FIG. 7 illustrates an example of a method for sensor control of a drill rig; and

FIG. 8 illustrates an example of a method for a sensor of a drill rig to transition to a power saving mode.

[0011] Like references are used to designate like parts in the accompanying drawings.

DESCRIPTION

[0012] Reference will now be made to embodiments, examples of which are illustrated in the accompanying drawings. The 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.

[0013] Drill rigs may be configured with a large number of sensors to provide feedback control for various functions, such as for example boom movement or drilling. Power supply to the sensors may be provided by wires, but it may be difficult to route the wires to desired parts of the drill rig. Furthermore, in case of mounting sensors to movable parts of the drill rig, the wires may get tangled and this may result in malfunction of the sensors. Wireless battery-powered sensors may be used to provide a more robust solution, but this comes with the need to replace or recharge the battery from time to time. Long battery life is therefore one of the requirements for a battery-powered sensor. Battery life may be extended by increasing the battery capacity, but this approach has a number of associated disadvantages, such as for example increased size, weight and price. Example embodiments of the present disclosure enable to reduce power consumption of sensors of a drill rig. In case of battery-powered sensors this results in longer battery life, less need for maintenance, and therefore improved overall efficiency.

[0014] FIG. 1 illustrates an example of an underground drill rig. Underground drill rig 100 may be a rock drilling rig. Underground drill rig 100 may comprise a movable carrier 110 and at least one boom 120 connected to movable carrier 110. Movable carrier 110 may comprise equipment for moving or stabilising underground drill rig 100, such as for example a motor, wheels, or stabilizer jack(s) 118. A stabilizer jack may be also referred to as a ground support member. Even though two booms 120 have been illustrated in FIG. 1, underground drill rig 100 may generally comprise one or a plurality (e.g. two, three, four,...) of booms 120.

[0015] A tool, represented in this example by drilling unit 130, may be coupled to a distal end portion of boom 120. Drilling unit 130 may comprise a feeding system configured to keep a drill bit of drilling unit 130 in contact with the drilling face, in this example tunnel surface 140, and to enable a drill rod to move along a feed beam during drilling. Boom(s) 120 may comprise a plurality of boom parts coupled to each other, movable carrier 110, and/or drilling unit 130 by joint(s) 122. Controllable joints enable drilling unit 130 to be placed at a desired position and orientation with respect to the drilling face.

[0016] FIG. 2 illustrates an example of a surface drill

rig. Surface drill rig 200 may comprise movable carrier 110 and mast 150. Drilling unit 130 may be located at the lower distal end of mast 150. Mast 150 may be supported by boom 120. Surface drill rig 200 may comprise tracks 160, which may be connected to movable carrier 110 to enable movement of surface drill rig 200. Surface drill rig 200 may be therefore a track-mounted drill rig. Surface drill rig 200 may comprise one or more of the parts described above with reference to FIG. 1, or other tool(s) or equipment relevant for a drill rig.

[0017] Underground drill rig 100 and surface drill rig 200 may be generally referred to as drill rig 100, 200. It is however noted that example embodiments of the present disclosure may be applied to other types of drill rigs, or mining machines in general (e.g., mining trucks, mining loaders, bolter miners, road headers, or multitaskers).

[0018] Drill rig 100, 200 comprise a rig controller (C) 112. Rig controller may be configured to control various functions of drill rig 100, 200, such as for example navigation, movement (e.g., tramming), or drilling. Rig controller 112 may for example comprise a navigation application configured to control, or enable a human operator to control, navigation of drill rig 100, 200. The navigation application may be for example configured to control movement of drill rig 100, 200 to a desired drilling position. Drilling position may refer to a position of carrier 110, from which drill rig 100, 200 is able to perform drilling. For example, a drilling position may comprise a position of the carrier in which at least one planned drill hole is within a reach of the drilling unit. Rig controller 112 may comprise control circuitry for performing functionality of rig controller 112, as described herein. Navigation of drill rig 100, 200 may comprise monitoring a position of drill rig 100, 200 and controlling movement of drill rig 100, 200 to a desired position, for example a planned drilling position.

[0019] Drill rig 100, 200 may comprise sensor(s) 116, which may be mounted at various parts of drill rig 100, 200, for example carrier 110. Alternatively, or additionally, sensor(s) 116 may be located at particular component(s) of drill rig 100, 200, such as for example boom 120 or mast 150, or a tool of drill rig 100, 200 (e.g., drilling unit 130). Sensor(s) 116 may comprise various types of sensors, such as for example an inertial measurement unit (IMU), an accelerometer, a gyroscope, a camera, a radio detection and ranging (radar) sensor, a light detection and ranging (lidar) sensor, or the like.

[0020] IMU, accelerometer, and/or gyroscope may be configured to measure or monitor angle(s), e.g., inclination angle, of component(s) and/or their positions with respect to drill rig 100, 200. One example of such a sensor is a boom angle sensor, which may be configured to measure angle(s) of boom 120. Boom angle sensor may be located at boom 120.

[0021] Some of sensor(s) 116 may be configured to scan environment of drill rig 100, 200, for example the drilling face. For example, a camera may be used to extract depth information of the drilling face, e.g., by comparing two images taken at slightly different position

(e.g., by two camera units). Alternatively, sensor(s) 116 may comprise a time-of-flight (ToF) camera, which may be configured to determine a distance between the camera and points of the drilling face or other objects by measuring a round-trip time of an artificial light signal provided by a laser or a light-emitting diode (LED). A lidar sensor may be configured to determine a distance to different points of the drilling face or other objects by targeting them with a laser and measuring the time for the reflected light to return to a receiver of the lidar sensor. A radar sensor may be configured to transmit electromagnetic energy towards drilling face or other objects and to observe the returned echoes to determine distances to different points of the drilling face or other objects.

[0022] Drill rig 100, 200 may comprise a sensor controller (SC) 114, which may be configured to control operation of sensor(s) 116. Sensor controller 114 may comprise sensor control circuitry for performing functionality of sensor controller 114, as described herein. Rig controller 112 and/or sensor controller 114 may be provided for example as an integrated circuit (IC), or, as a software application residing on at least one memory and being executable by a processor. An example of an apparatus suitable for implementing rig controller 112 and/or sensor controller 114 is provided in FIG. 6. Rig controller 112 may comprise, or be communicatively coupled to, various functions, blocks, or applications for controlling functionality of drill rig 100, 200.

[0023] Sensor(s) 116 may be battery powered. This provides the benefit of more robust installation of the sensor system, because installation of wires for supplying power may be avoided. Wires may be prone to damage when moving components of drill rig 100, 200, for example boom(s) 120 or mast 150. Sensor(s) 116 may be equipped with communication circuitry, for example wireless radio transmitter and/or receiver circuitry coupled to one or more antennas, in order to enable sensor(s) 116 to wirelessly transmit and/or receive information, for example data capture by sensor(s). The communication circuitry may be configured to provide a wireless communication interface between sensor(s) 116 and drill rig 100, 200, for example rig controller 112 or sensor controller 114. An example of a suitable wireless communication interface for implementing wireless communication links described herein is Bluetooth® Low Energy (LE).

[0024] As noted above, extended battery life is one of the desired properties of a battery-powered sensor system. Sensor controller 114 may be therefore configured to determine some or all of sensor(s) 116 to be transitioned to a power saving mode depending on the current operational status of drill rig 100, 200, or component(s) thereof. This enables power consumption of the sensor(s) to be reduced, when they are not needed for controlling operations of drill rig 100, 200.

[0025] Operational status may be indicative of current functionality or capability(ies) of drill rig 100, 200. For example, operational status may indicate a current con-

figuration of drill rig 100 200, or component(s) or tool(s) thereof, for example their position/orientation, enablement/disablement, or the like. Operational status may indicate whether drill rig 100, 200, or component(s) or tool(s) thereof, is currently operating (e.g., performing a particular function) or moving, or has operated or moved within a certain time period.

[0026] Operational status may comprise a designated operating mode of drill rig 100, 200. The designated operating mode may be selected, for example by rig controller 112, from an enumerated list of possible operating modes, such as for example 'active', 'inactive', 'enabled', 'disabled', 'drilling', 'tramming', 'failure', or the like. Being active may generally refer to a state, where the respective equipment is currently operating (e.g., performing a function such as drilling). Being inactive may generally refer to a state, where the respective equipment is currently not operating or operable. Being enabled may generally refer to a state, where the respective equipment is currently operational, but not necessarily being currently operated. Being disabled may generally refer to a state, where operation of the respective equipment is prevented or restricted. The operating mode of drill rig 100, 200 may correspond to a current state of an internal state machine of drill rig 100, 200. A state machine may comprise a software component that models system behaviour by defining a finite set of predefined states of the system and transition between the states. A state comprises a description of a status of a system such as a drill rig that is performing an operation or waiting for a transition from a first state to a second state. A state of a drill rig may comprise, for example, a current state of the drill rig. A current state of the drill rig may comprise, for example, an idle state in which the drill rig is waiting for a signal to start an operation. As another example, a current state may comprise an operation state indicative of operational status of the drill rig performing a predefined operation.

[0027] Internal structure of a sensor may be divided into sensing unit(s), such as for example IMU, accelerometer, gyroscope, or the like, and other sensor circuitry, such as for example processor(s) (e.g., central processing unit, CPU) and/or communication circuitry. In case of some sensors, the sensing units may consume a significant amount of the total power consumption of the sensor. A power saving mode of a sensor may comprise partially powering down or completely switching off all or a subset of sensing unit(s) of the sensor. Alternatively, or additionally, power consumption of the processor(s) may be configured to be reduced in the power saving mode, for example by lowering the clock frequency of the processor(s). Furthermore, power consumption of the communication circuitry may be configured to be reduced in the power saving mode, for example by configuring the communication circuitry to transmit/receive data less frequently. Power consumption may be also reduced by switching off (unnecessary) data line(s) or bus(es) of the sensor. In the power saving mode the communica-

tion circuitry and/or processor may be still configured to operate at a sufficient level, in order to enable the sensor to receive and process instructions for transitioning from the power saving mode back to normal operating mode.

[0028] Drill rig 100, 200 may be an automated drill rig, for example an automated underground drill rig or an automated surface drill rig. An automated drill rig, operating in an automatic mode may be configured to, for example, receive a task to be performed, perceive the environment of the drill rig and autonomously perform the task while taking the environment into account. An automated drill rig operating in an automatic mode may be configured to operate independently but may be taken under external control at certain operation areas or conditions, such as during states of emergencies.

[0029] FIG. 3 illustrates an example of communication links between a sensor controller, a rig controller, and sensor(s) of a drill rig. Sensor controller 114 may be connected to rig controller 112 by a wireless or wired communication link. Examples of wireless communication links include any short-range wireless networks, such as for example Bluetooth or Wi-Fi networks, wireless serial data interfaces, or the like. A wired communication link may for example comprise a serial data interface, or the like. In some embodiments, the sensor controller 114 may be implemented as part of rig controller 112, or coupled to rig controller 112 via an internal communication interface of drill rig 100, 200, for example a data bus interface.

[0030] Sensor(s) 116 may be configured to transmit sensor signals to sensor controller 114 and/or rig controller 116. The sensor signal(s) may include sensor data, for example sensor readings. The sensor data may be obtained by measurements performed by sensing unit(s) of sensor(s) 116. Sensor controller 114 may be configured to transmit sensor control signal(s) to sensor(s) 116, for example to request sensor(s) 116 to be transitioned to the power saving mode. Even though illustrated as unidirectional links in FIG. 3, the communication links may be bidirectional.

[0031] The wireless communication links to different sensor(s) may comprise separate wireless communication links to each sensor. Different sensor(s) may be however configured to use a common wireless communication signal, for example by means of time-division multiplexing. Any communication link enabling addressable communication with a particular sensor may be considered as a separate communication link. For example, sensor controller 114 may be configured to transmit sensor control signals (e.g., request to enter power saving mode) to sensor 116-1 over a first wireless communication link ("1st link"). Sensor 116-1 may be configured to monitor operation of drill rig 100, 200, for example in particular operational status(es) of drill rig 100, 200. Sensor 116-1 may be therefore configured to be transitioned to the power saving mode, if sensor 116-1 is not needed in some operational status of drill rig 100, 200. Sensor controller 114 may be configured to receive sen-

sor signal(s) from sensor 116-2 over a second wireless communication link ("2nd link"). The first and second wireless communication links may be provided using different radio technologies, different frequencies, or different time slots of the same wireless communication signal. A sensor signal may include sensor data captured by a sensor at one or more time instants. Sensor 116-2 may be configured to monitor drill rig 100, 200 regardless of the operational status of drill rig 100, 200. Sensor signal(s) from sensor 116-2 may be therefore used for determining the operational status of drill rig 100, 200.

[0032] As mentioned above, the communication link ("3rd link") between rig controller 112 and sensor controller 114 may comprise a wireless communication link.

This may be the case for example if sensor controller 114 is integrated within a sensor 116. Considering the above options, sensor controller 114 may be configured to transmit sensor control signals to sensor(s) (e.g., sensor 116-1) over the first wireless communication link. Sensor controller 114 may be configured to receive sensor signal(s) from other sensor(s) (e.g., sensor 116-2) or control signals from rig controller 112 over another wireless communication link ("2nd link" or "3rd link"). In case of sensor signals, the another communication link may be the second wireless communication link. In case of control signals, the another wireless communication link may be the third wireless communication link.

[0033] FIG. 4 illustrates an example of signalling and operations for controlling sensor(s) of a drill rig to transition to a power saving mode based on operational status of the drill rig. Operations of FIG. 4 are described as sensor 116-1 being the sensor that is configured to be transitioned to the power saving mode and sensor 116-2 operating as an external sensing unit, also referred to as another sensor, optionally assisting in determination of the operational status of drill rig 100, 200. It is however noted that sensor controller 114 may be configured to control power saving mode of more than one sensor and to receive sensor signals from more than one sensor.

[0034] At operation 401, sensor 116-2 may be configured to read sensor data, for example as measured by sensing unit(s) of sensor 116-2. Sensor 116-2 may be configured to read the sensor data at one or more time instants, for example periodically. The type of the sensor data may be dependent on the type of sensor 116-2. For example, an accelerometer may be configured to read sensor data as one or more values of acceleration, for example with respect to three mutually orthogonal axes. A gyroscope may be configured to read values of an orientation of the sensor or an angular velocity of the sensor.

[0035] At operation 402, sensor 116-2 may be configured to transmit sensor signal(s) to sensor controller 114. Transmission of the sensor signal(s) may be over a wireless communication link (cf. "2nd link" of FIG. 3). Alternatively, or additionally, sensor(s) 116-2 may be configured to transmit the sensor signal(s) directly to rig controller 112, for example over another wireless

communication link ("4th link").

[0036] At operation 403, rig controller 112 may be configured to transmit control signal(s) to sensor controller 114. Rig controller 112 may be configured to determine the content of the control signal(s) based on internal control data of drill rig 100, 200, for example status of various components of drill rig 100, 200 as recorded in memory associated with rig controller 112 (e.g., actuators such as electric actuators, or hydraulic power packs enabled or disabled, motor running or not, drill rig moving or not, etc.). For example, rig controller 112 may be configured to read a current state of a state machine of drill rig 100, 200, e.g., "drilling", "tramming", "navigated", or the like. Rig controller 112 may be configured to determine the current operational status of drill rig 100, 200 based on the current state of the state machine. Rig controller 112 may be configured to determine the control signal(s) based on the current state of the state machine. For example, the control signal(s) may include an indication of the current state of the state machine as the operational status of drill rig 100, 200. Alternatively, or additionally, rig controller 112 may be configured to determine the control signal(s) based on the sensor signal(s) received from sensor 116-2. An indication of operational status, or in general any information, may comprise a designated value of an information field of a control signal, such as for example a bit or a group of bits having particular value(s).

[0037] The control signal(s) may be indicative of the operational status of either drill rig 100, 200, or component(s) of drill rig 100, 200. The control signal(s) may be indicative of movement of carrier 110, for example by indicating a status of movement of carrier 110, such as for example 'moving', 'tramming', 'not moving', or 'not tramming'. As another example, the control signal(s) may be configured to indicate the speed of carrier 110. Rig controller 112 may be for example configured to configure the control signal(s) with an indication that drill rig 100 is moving, in response to determining that consecutive positioning signals, as received from positioning sensor(s) coupled to drill rig 100, 200, are indicative of movement of drill rig 100, 200.

[0038] The control signal(s) may comprise an indication of a position of drill rig 100, 200, for example in an external reference coordinate frame stationary with respect to ground, or, with respect to a planned drilling position. For example, if drill rig 100, 200 has not yet been navigated to the planned drilling position, rig controller 112 may be configured to configure the control signal(s) to comprise a status indication of 'not navigated'. In general, if drill rig is not located at the planned drilling position, rig controller 112 may be configured to configure the control signal(s) to comprise a status indication of 'not located at planned drilling position', or the like.

[0039] The control signal(s) may be associated with powering component(s) or tool(s) of drill rig 100, 200. For example, the control signal(s) may comprise an indication

of operational status of actuator(s), e.g., electric actuator(s), or hydraulic power pack(s) of drill rig, 100, 200 for example 'disabled' or 'enabled'. The operational status of the actuator(s) or hydraulic power pack(s), or in general any other powering equipment, may be associated with particular component(s) of drill rig 100, 200, for example boom 130 or mast 150.

[0040] The control signal(s) may comprise an indication of the current operating mode of drill rig 100, 200. While some control signals may implicitly reflect the operational status of drill rig by means of providing information associated with current functionality of drill rig 100, 200, an operating mode may comprise an explicit designation of a mode of operation assigned to drill rig 100, 200, or component(s) or tool(s) thereof, for example by rig controller 112. The operating mode may be based on an enumerated list of possible operating modes, as described above.

[0041] Control signal(s) may comprise an indication of the status of particular component(s) of drill rig 100, 200. For example, control signal(s) may comprise an indication of the status of stabilizer jack(s) 118 (e.g., positioned to ground or not), the motor of drill rig 100, 200 (e.g., running or not), or boom 120 or mast 150 (e.g., placed in tramming position or not).

[0042] Sensor controller 114 may be configured to obtain information on the current operational status of drill rig 100, 200 based on the control signal(s) received at operation 403 and/or based on the sensor signal(s) received at operation 402 and/or. Sensor controller 114 may be configured to obtain the information of the operational status directly, for example by receiving an explicit indication of the current operating mode of drill rig 100, 200, or component(s) or tool(s) thereof, in the control signal(s). For example, sensor controller 114 may be configured to obtain information on status of the motor of drill rig 100, 200 by receiving a control signal indicative of the motor being running or not running.

[0043] Alternatively, sensor controller 114 may be configured to obtain the information on the operational status by determining (e.g., deducing) the operational status of drill rig 100, 200 based on the control signal(s) and/or sensor signal(s), as will be further described below.

[0044] At operation 405, sensor controller 114 may be configured to determine operational status of drill rig 100, 200. Sensor controller 114 may be configured to determine the operational status based on implicit indications of the operational status. The operational status may be the current operational status of drill rig 100, 200, which may refer to the operational status at the time of capturing the sensor data by sensor 116-2 or determining the control signal(s) by rig controller 112. Examples of determining the operational status based on the various indications of the control signal(s) are provided in the following paragraphs.

[0045] Sensor controller 114 may be configured to determine a motional status of drill rig 100, 200, which is provided as one example of an operational status. The

motional status may indicate whether carrier 110 is moving or whether it is stationary. Sensor controller 114 may be configured to determine that carrier 110 is moving (e.g., tramming), for example in response to receiving control signal(s) indicative of the speed of carrier 110 being above a threshold. Alternatively, or additionally, sensor controller 114 may be configured to determine that carrier 110 is moving, in response to receiving consecutive control signals indicative of change of position of carrier 110. Further, sensor controller 114 may be configured to determine that carrier 110 is not moving, in response to receiving control signal(s) indicative of at least one of stabilizer jack(s) 118 being positioned to ground and/or the motor of drill rig 100, 200 not being running. On the other hand, sensor controller 114 may be configured to determine that carrier 110 is moving, or is likely to be moved, in response to receiving control signal(s) indicative of (all) stabilizer jack(s) 118 not being positioned to ground (e.g., lifted up). The motional status may therefore indicate either the current motional status or a predicted motional status. This provides the benefit of enabling proactive power control of sensor 116-1.

[0046] Sensor controller 114 may be configured to determine a positional status of drill rig 100, 200, which is provided as another example of an operational status. Positional status may comprise information on position of drill rig 100, 200, for example with respect to a reference position. The reference position may comprise a planned operating position, such as for example a planned drilling position. The positional status may for example indicate whether drill rig 100, 200 is located at the planned drilling position, e.g., whether drill rig 100, 200 has already been navigated to the planned drilling position. The planned drilling position may comprise a position at a reference coordinate frame stationary with respect to ground. Being located at the planned drilling position may comprise being sufficiently close to the planned drilling position such that drill rig 100, 200 is able to perform a planned drilling task, e.g., to drill holes according to a drilling plan. Alternatively, being at the planned drilling position may comprise being within a range from the planned drilling position. This provides again the benefit of enabling proactive power control of sensor 116-1 as it can be powered up already when approaching the planned drilling location.

[0047] The operational status of drill rig 100, 200 may be associated with powering component(s) or tool(s) of drill rig 100, 200. An example of such operational status is hydraulic power status. For example, sensor controller 114 may be configured to determine that hydraulic power pack(s) of drill rig 100, 200, or component(s) or tool(s) thereof (e.g., boom 120), are disabled. This may be in response to receiving corresponding control signal(s) from rig controller 112. It is noted that hydraulic power packs are provided as one example of powering component(s) or tool(s) of drill rig 100, 200. Alternatively, or additionally, actuator(s), e.g., electric actuator(s), may be used for moving component(s) or tool(s) of drill rig 100,

200.

[0048] Yet another example of an operational status of drill rig 100, 200 is the failure status. The failure status may indicate whether drill rig 110, 200, or particular component(s) or tool(s) thereof, are in a failure mode or not. Sensor controller 114 may be configured to determine the failure status based on corresponding control signal(s) received from rig controller 112. Being in the failure mode may indicate that the respective equipment is not functional.

[0049] At operation 406, sensor controller 114 may be configured to determine, based on the operational status of drill rig 100, 200, that sensor 116-1 is to be transitioned to a power saving mode. In general, sensor controller 114 may be configured to determine, from the plurality of sensors 116, the sensor(s) to be transitioned to the power saving mode based on the determined sensor(s) being associated with function(s), component(s), or tool(s) that are disabled in accordance with the determined operational status. In general, sensor controller 114 may be configured to determine sensor 116-1 to be transitioned to the power saving mode, in response to determining at least one condition on the operational status of drill rig 100, 200 to be fulfilled. Examples of the conditions for causing sensor 116-1 to be transitioned to the power saving mode are provided below.

[0050] For example, sensor controller 114 may be configured to determine sensor(s) associated with drilling, e.g., sensor(s) located at drilling unit 130, to be transitioned in the power saving mode, in response to determining that drill rig 100, 200 is not located at the planned drilling position, or in response to determining that drill rig 100, 220 is tramming, or in response to determining that stabilizer jack(s) of drill rig 100, 200 are not positioned to ground. In general, sensor controller 114 may be configured to determine any sensor(s) associated with tool(s) of drill rig 100, 200 to be transitioned to the power saving mode, in response to determining the motional status being indicative of carrier 110 to be moving or to be predicted to move. This provides the benefit of avoiding unnecessary power consumption by the sensors that are not needed during movement of carrier 110.

[0051] Sensor controller 114 may be configured to determine any sensor(s) associated with tool(s) of drill rig 100, 200 to be transitioned to the power saving mode, in response to determining the positional status being indicative of drill rig 100, 200 not being located at a planned position for applying the tool. For example, sensor controller 114 may be configured to determine any sensor(s) associated with drilling unit 130 to be transitioned to the power saving mode, in response to determining the positional status being indicative of drill rig 100, 200 not being located at the planned drilling position. This provides the benefit of avoiding unnecessary power consumption by sensors that are not needed when not using the tool.

[0052] Sensor controller 114 may be configured to

determine sensor(s) located at boom 120 to be transitioned in the power saving mode, in response to determining that actuator(s), e.g., electric actuator(s), or hydraulic power pack(s) of boom 120 are disabled. In general, sensor controller 114 may be configured to determine any sensor(s) affected by disabling particular actuator(s) or hydraulic power pack(s) of drill rig 100, 200 to be transitioned in the power saving mode, in response to determining the respective actuator(s) or hydraulic power pack(s) of drill rig 100, 200 to be disabled. This provides the benefit of avoiding unnecessary power consumption of sensor(s) located at boom 120 or other parts of drill rig 100, 200, which are not operable due to disabling of the actuator(s) or hydraulic power pack(s).

[0053] Sensor controller 114 may be configured to determine sensor(s) of drill rig 100, 200 to be transitioned in the power saving mode, in response to determining that drill rig 100, 200 is in a failure mode or that motor of drill rig 100, 200 is not running. Sensor controller 114 may be configured to determine sensor(s) of a component or tool of drill rig 100, 200 to be transitioned in the power saving mode, in response to determining that this component or tool is the failure mode. This provides the benefit of avoiding unnecessary power consumption of sensor(s) located at drill rig 100, 200, or component(s) or tool(s) thereof, which are not needed due to failure mode or the drill rig being otherwise non-functional.

[0054] Sensor controller 114 may be configured to determine the operational status of drill rig 100, 200 based on sensor signal(s) received from sensor 116-2, or in general other sensor(s). The other sensor(s) may be also referred to as external sensing unit(s) and they may not be subject to transitioning to the power saving mode. For example, boom 120 may comprise a first sensor (cf. sensor 116-2) configured for motion detection (e.g., continuous or periodical motion detection) of boom 120 as an external sensing unit. Sensor controller 114 may be configured to determine, based on the sensor data of the first sensor, whether a second sensor (cf. sensor 116-1) of boom 120 is to be transitioned to the power saving mode or whether power saving mode of the second sensor is to be terminated. The second sensor may be more accurate than the first sensor and therefore also consume more power. This provides the benefit of enabling to monitor the operational status of drill rig 100, 200, or component(s) or tool(s) thereof, with low power sensor(s) and to transition more accurate but higher power sensor(s) to the power saving mode when not needed.

[0055] At operation 407, sensor controller 114 may be configured to transmit to 116-1 sensor control signal(s), for example a request to transition to the power saving mode. Considering the example of FIG. 3, sensor controller 116 may be configured to transmit the request over the first wireless communication link ("1st link"), which may be a different link from the second wireless communication link ("2nd link"), from which sensor controller 114 may have received the sensor signal(s) at operation 402.

Sensor controller 114 may be configured to transmit the request, in order to cause sensor 116-1 to transition to the power saving mode. Sensor controller may be configured to transmit the request, or a similar request, to any sensors determined at operation 406.

[0056] The examples of FIG. 4 enable powering down sensors of drill rig 100, 200, when the operational status of drill rig 100, 200 is such that the sensors are not needed. This enables to lower power consumption of the sensors and, in case of battery-powered sensors, to increase battery lifetime. More robust sensor system may be therefore implemented without needing to change batteries of the sensors too often. It is however noted that some operations of FIG. 4 might not be present in all example embodiments. For example, operations 402 and 403 may be optional, because sensor controller 114 may be configured to perform operations 405, 406, 407 based on the sensor signal(s) without the control signal(s), based on the control signal(s) without the sensor signal(s), or based on both the sensor signal(s) and the control signal(s).

[0057] FIG. 5 illustrates an example of signalling and operations of a sensor for transitioning to a power saving mode based on operational status of a drill rig. Operations similar to those described for sensor controller 114 with reference to FIG. 4 may be performed by sensor 116-1. For example, sensor 116-1 may comprise sensor controller 114, which may be configured to determine whether sensor 116-1 itself is to be transitioned to the power saving mode. Functionality of sensor 116-1 described herein may be therefore implemented by a sensor controller 114 integrated within sensor 116-1.

[0058] At operation 501, sensor 116-1 may be configured to read sensor data, for example from sensing unit(s) of sensor 116-1, for example as described for sensor 116-2 with reference to operation 401. Sensor 116-1 may be configured to provide the sensor data to sensor controller 114 within sensor 116-1, for example over an internal communication interface.

[0059] At operation 502, sensor 116-1 may be configured to receive sensor signal(s) from sensor 116-2, for example as described with reference to operation 402.

[0060] At operation 503, sensor 116-1 may be configured to determine whether the wireless communication link to drill rig 100, 200, for example to rig controller 112, is inactive. Sensor 116-1 may be configured to determine whether or not data is received from rig controller 112, for example whether or not rig controller 112 responds to requests transmitted by sensor 116-1 via the wireless communication link. Sensor 116-1 may be configured to determine that status of the wireless communication link is inactive, if no data is received from rig controller 112, or rig controller does not respond to the request, during a predetermined time period, or if the link is otherwise in a non-connected state. Considering the example of FIG. 3, this wireless communication link may comprise the third wireless communication link ("3rd link") of FIG. 3. In this example, sensor controller 114 may be however located

at sensor 116-1, contrary to the illustration of FIG. 3.

[0061] At operation 504, sensor 116-1 may be configured to determine operational status of drill rig 100, 200. Sensor 116-1 may be configured to determine the operational status of drill rig 100, 200 based on its own sensor data read at operation 501, based on the sensor signal(s) received from sensor 116-2, or based on the status of the wireless communication link to drill rig 100, 200.

[0062] Sensor 116-1 may be configured to determine operational status of drill rig 100, 200, or a component or tool associated with sensor 116, to be inactive, in response to determining that sensor reading(s) of sensor 116-1 are substantially constant, for example for a predetermined time period (duration). Being substantially constant may comprise sensor readings varying within a predetermined range of values. For example, sensor 116-1 may be configured to determine operational status of drill rig 100, 200, or a component or tool associated with sensor 116, to be inactive, in response to determining that sensor 116-1 is stationary. Determining that sensor 116-1 is stationary may comprise determining that sensor 116-1 is substantially stationary, for example that sensor readings (e.g., acceleration) of sensor 116-1 are within a predetermined range around zero. Alternatively, sensor 116-1 may be configured to determine operational status of drill rig 100, 200, or a component or tool associated with sensor 116, to be inactive, in response to determining that a pressure level measured by sensor 116-1 is substantially constant.

[0063] Sensor 116-1 may be configured to determine the operational status of drill rig 100, 200 to be inactive based on the sensor signal(s) received from sensor 116-2, or other sensors in general. For example, an accurate high-power sensor may be configured to receive sensor signals from a less accurate low-power sensor, in order to determine whether to keep the high-power sensor active or whether to transition the high-power sensor to the power saving mode.

[0064] Sensor 116-1 may be configured to determine the operational status of drill rig 100, 200 to be inactive based on inactivity of the wireless communication link, for example in response to determining that the wireless communication link has been inactive for a predetermined time period. Duration of this time period may or may not be the same as the duration of the time period used for determining that sensor readings of sensor 116-1 are substantially constant. Sensor 116-1 may be configured to determine to transition itself to the power saving mode, in response to determining drill rig 100, 200, e.g. particular component(s) or tool(s) thereof, to be inactive.

[0065] At operation 505, sensor 116-1 may be configured to transition to the power saving mode. For example, sensor controller 114 may be configured to power down sensing unit(s) and/or a processor (e.g., CPU) of sensor 116-1, in response to determining that sensor 116-1 is to be transitioned to the power saving mode.

[0066] The examples of FIG. 5 therefore enable an

individual sensor to independently determine to transition to a power saving mode, when the operational status is such that the sensor is not needed for operation of drill rig 100, 200.

[0067] Sensor controller 114 may be configured to continue obtaining information on the operational status of drill rig 100, 200 when sensor 116-1 is in the power saving mode, for example by monitoring the control signal(s) or sensor signal(s). Sensor controller 114 may be configured to cause termination of the power saving mode of sensor 116-1, in response to determining that the operational status of drill rig 116-1 no longer fulfills at least one of the conditions for transitioning sensor 116-1 to the power saving mode. This enables sensor 116-1 to be taken into use whenever the operational status of drill rig 100, 200 is such that sensor data from sensor 116-1 is beneficial for operation of drill rig 100, 200.

[0068] FIG. 6 illustrates an example of an apparatus configured to practise one or more example embodiments. Apparatus 600 may be or comprise sensor controller 114 or one of sensors 116, or in general any device or system configured to implement the functionality described herein. Although apparatus 600 is illustrated as a single device, it is appreciated that, wherever applicable, functions of apparatus 600 may be distributed to a plurality of devices.

[0069] Apparatus 600 may comprise at least one processor 602. The at least one processor 602 may comprise, for example, one or more of various processing devices, such as for example a co-processor, a micro-processor, 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, or the like.

[0070] Apparatus 600 may further comprise at least one memory 604. The at least one memory 604 may be configured to store, for example, computer program code or the like, for example operating system software and application software. The at least one memory 604 may comprise one or more volatile memory devices, one or more non-volatile memory devices, and/or a combination thereof. For example, the memory may be embodied as magnetic storage devices (such as hard disk drives, etc.), optical magnetic storage devices, or semiconductor memories (such as mask ROM, PROM (programmable ROM), EPROM (erasable PROM), flash ROM, RAM (random access memory), etc.). Memory 604 is provided as an example of a (non-transitory) computer readable medium. The term "non-transitory," as used herein, is a limitation of the medium itself (i.e., tangible, not a signal) as opposed to a limitation on data storage persistency (e.g., RAM vs. ROM). The at least one memory 604 may be also embodied separate from apparatus 600, for ex-

ample as a computer readable (storage) medium, examples of which include memory sticks, compact discs (CD), or the like.

[0071] When apparatus 600 is configured to implement some functionality, some component and/or components of apparatus 600, such as for example the at least one processor 602 and/or the at least one memory 604, may be configured to implement this functionality. Furthermore, when the at least one processor 602 is configured to implement some functionality, this functionality may be implemented using program code 606 comprised, for example, in the at least one memory 604.

[0072] The functionality described herein may be performed, at least in part, by one or more computer program product components such as software components. According to an example embodiment, apparatus 600 comprises a processor or processor circuitry, such as for example a microcontroller, configured by program code 606, when executed, to execute the embodiments of the operations and functionality described herein. Program code 606 is provided as an example of instructions which, when executed by the at least one processor 602, cause performance of apparatus 600.

[0073] For example, functionality of rig controller 112, sensor controller 114, or sensor(s) 116 may be at least partially implemented as program code configured to cause apparatus 600 to perform their functionality, respectively. Similarly, transmission or reception of data, e.g., sensor signals or control signals, over an internal or external communication interface of drill rig 100, 200 or sensor(s) 116 may be controlled by software.

[0074] 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), graphics processing units (GPUs), neural processing unit (NPU), tensor processing unit (TPU), or the like.

[0075] Apparatus 600 may comprise a communication interface 608 configured to enable apparatus 600 to transmit and/or receive information. Communication interface 608 may comprise an internal or external communication interface, such as for example a wireless communication interface (radio interface) or wired communication interface, for example as described with reference to FIG. 3.

[0076] Apparatus 600 may further comprise other components and/or functions such as for example a user interface (not shown) comprising at least one input device and/or at least one output device. The input device may take various forms such as a keyboard, a touch screen, or one or more embedded control buttons, joysticks, or other type of manual controllers. The output device may for example comprise a display, a speaker, or

the like. The user interface may be configured to enable a human operator to monitor various functions, data, or the like.

[0077] Apparatus 600 may be configured to perform or cause performance of any aspect of the method(s) described herein. Further, a computer program, a computer program product, or a (non-transitory) computer readable memory may comprise instructions for causing, when executed by apparatus 600, apparatus 600 to perform any aspect of the method(s) described herein. Further, apparatus 600 may comprise means for performing any aspect of the method(s) described herein. In one example, the means comprises the at least one processor 602, the at least one memory 604 including program code 606 (instructions) configured to, when executed by the at least one processor 602, cause apparatus 600 to perform the method(s). In general, computer program instructions may be executed on means providing generic processing functions. Such means may be embedded for example in a computer, a server, or the like. The method(s) may be thus computer-implemented, for example based algorithm(s) executable by the generic processing functions, an example of which is the at least one processor 602. Apparatus 600 may comprise means for transmitting or receiving information, for example one or more wired or wireless (e.g., radio) transmitters or receivers, which may be coupled or be configured to be coupled to one or more antennas, or transmitter(s) or receiver(s) of a wired communication interface.

[0078] According to a first aspect, an apparatus for sensor control of a drill rig is disclosed. The apparatus may comprise: at least one processor; and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to: obtain information on operational status of the drill rig; determine, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and cause the at least one sensor of the drill rig to transition to the power saving mode.

[0079] According to an example embodiment of the first aspect, the at least one memory and the computer program are code configured to, with the at least one processor, cause the apparatus to: determine the operational status of the drill rig based on at least one control signal provided by control circuitry of the drill rig.

[0080] According to an example embodiment of the first aspect, the at least one control signal is indicative of movement of a carrier of the drill rig or a position of the drill rig.

[0081] According to an example embodiment of the first aspect, the at least one control signal is indicative of: the drill rig not being located at a planned drilling position, or the drill rig being tramming.

[0082] According to an example embodiment of the first aspect, the at least one control signal is associated

with powering a component of the drill rig or a tool of the drill rig.

[0083] According to an example embodiment of the first aspect, the at least one control signal is indicative of: at least one actuator or hydraulic power pack of the drill rig being disabled; or at least one actuator or hydraulic power pack of a boom of the drill rig being disabled, wherein the at least one sensor is located at the boom of the drill rig.

[0084] According to an example embodiment of the first aspect, the at least one control signal is indicative of: a failure mode of the drill rig or at least one component of the drill rig associated with the at least one sensor, at least one stabilizer jack of the drill rig not being positioned to ground, or a motor of the drill rig not being running.

[0085] According to an example embodiment of the first aspect, the at least one memory and the computer program are code configured to, with the at least one processor, cause the apparatus to: receive at least one sensor signal from at least one other sensor of the drill rig and determine the operational status of the drill rig based on the at least one sensor signal.

[0086] According to an example embodiment of the first aspect, the at least one memory and the computer program are code configured to, with the at least one processor, cause the apparatus to: determine, based on the at least one control signal or the at least one sensor signal, the operational status of the drill rig as at least one of: the drill rig not being located at the planned drilling position, the drill rig being tramming, the at least one actuator or hydraulic power pack of the drill rig being disabled, the at least one actuator or hydraulic power pack of the boom of the drill rig being disabled, the at least one stabilizer jack of the drill rig not being positioned to ground, the motor of the drill rig not being running, the drill rig or the component of the drill rig being in the failure mode; and determine to cause the at least one sensor of the drill rig to transition to the power saving mode, in response to determining the operational status of the drill rig as at least one of: the drill rig not the planned drilling position, the drill rig being tramming, the at least one actuator or hydraulic power pack of the drill rig being disabled, the at least one actuator or hydraulic power pack of the boom of the drill rig being disabled, the at least one stabilizer jack of the drill rig not being positioned to ground, the motor of the drill rig not being running, or the drill rig or the component of the drill rig being in the failure mode.

[0087] According to an example embodiment of the first aspect, the at least one sensor comprises a boom angle sensor, and/or the at least one sensor is a battery-powered sensor.

[0088] According to an example embodiment of the first aspect, the at least one memory and the computer program are code configured to, with the at least one processor, cause the apparatus to: transmit, to the at least one sensor, a request to transition to the power saving mode over a wireless communication link.

[0089] According to a second aspect, a sensor is disclosed. The sensor may comprise the apparatus according to any example embodiment of the first aspect, wherein the at least one memory and the computer program are code configured to, with the at least one processor, cause the apparatus to transition the sensor to the power saving mode based on the operational status of the drill rig.

[0090] According to an alternative embodiment of the second aspect, a sensor is disclosed. The sensor may comprise at least one processor; and at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the sensor to at least to: obtain information on operational status of a drill rig; determine, based on the operational status of the drill rig, to transition the at least one sensor to a power saving mode; and transition the sensor to transition to the power saving mode.

[0091] According to an example embodiment of the second aspect, the at least one memory and the computer program are code configured to, with the at least one processor, cause the apparatus or sensor to: receive the at least one control signal or the at least one sensor signal over another wireless communication link.

[0092] According to an example embodiment of the second aspect, the at least one memory and the computer program are code configured to, with the at least one processor, cause the apparatus or sensor to: determine to cause the sensor to transition to the power saving mode, in response to determining, based on a status of the another wireless communication link, that the drill rig is inactive; or determine to cause the sensor to transition to the power saving mode, in response to determining that a sensor reading of the sensor has been substantially constant for a predetermined time period.

[0093] FIG. 7 illustrates an example of a method for sensor control of a drill rig, according to a third aspect of the present disclosure. The method may comprise a computer-implemented method performed by, for example, apparatus 600 such as sensor controller 114 or sensor(s) 116.

[0094] At 701, the method may comprise obtaining information on operational status of the drill rig

[0095] At 702, the method may comprise determining, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode.

[0096] At 703, the method may comprise causing the at least one sensor of the drill rig to transition to the power saving mode.

[0097] According to an example embodiment of the third aspect, the method comprises: determining the operational status of the drill rig based on at least one control signal provided by control circuitry of the drill rig.

[0098] According to an example embodiment of the third aspect, the at least one control signal is indicative of movement of a carrier of the drill rig or a position of the drill

rig.

[0099] According to an example embodiment of the third aspect, the at least one control signal is indicative of: the drill rig not being located at a planned drilling position, or the drill rig being tramming.

[0100] According to an example embodiment of the third aspect, the at least one control signal is associated with powering a component of the drill rig or a tool of the drill rig.

[0101] According to an example embodiment of the third aspect, the at least one control signal is indicative of: at least one actuator or hydraulic power pack of the drill rig being disabled; or at least one actuator or hydraulic power pack of a boom of the drill rig being disabled, wherein the at least one sensor is located at the boom of the drill rig.

[0102] According to an example embodiment of the third aspect, the at least one control signal is indicative of: a failure mode of the drill rig or at least one component of the drill rig associated with the at least one sensor, at least one stabilizer jack of the drill rig not being positioned to ground, or a motor of the drill rig not being running.

[0103] According to an example embodiment of the third aspect, the method comprises: receiving at least one sensor signal from at least one other sensor of the drill rig and determine the operational status of the drill rig based on the at least one sensor signal.

[0104] According to an example embodiment of the third aspect, the method comprises: determining, based on the at least one control signal or the at least one sensor signal, the operational status of the drill rig as at least one of: the drill rig not being located at the planned drilling position, the drill rig being tramming, the at least one actuator or hydraulic power pack of the drill rig being disabled, the at least one actuator or hydraulic power pack of the boom of the drill rig being disabled, the at least one stabilizer jack of the drill rig not being positioned to ground, the motor of the drill rig not being running, the drill rig or the component of the drill rig being in the failure mode; and determining to cause the at least one sensor of the drill rig to transition to the power saving mode, in response to determining the operational status of the drill rig as at least one of: the drill rig not being located at the planned drilling position, the drill rig being tramming, the at least one actuator or hydraulic power pack of the drill rig being disabled, the at least one actuator or hydraulic power pack of the boom of the drill rig being disabled, the at least one stabilizer jack of the drill rig not being positioned to ground, the motor of the drill rig not being running, or the drill rig or the component of the drill rig being in the failure mode.

[0105] According to an example embodiment of the third aspect, the at least one sensor comprises a boom angle sensor, and/or the at least one sensor is a battery-powered sensor.

[0106] According to an example embodiment of the third aspect, the method comprises: transmitting, to the at least one sensor, a request to transition to the power

saving mode over a wireless communication link.

[0107] According to an example embodiment of the third aspect, the method may be performed by a sensor, the method comprising: transitioning the sensor to the power saving mode based on the operational status of the drill rig.

[0108] According to an example embodiment of the third aspect, the method comprises: receiving the at least one control signal or the at least one sensor signal over another wireless communication link.

[0109] According to an example embodiment of the third aspect, the method comprises: determining to cause the sensor to transition to the power saving mode, in response to determining, based on a status of the another wireless communication link, that the drill rig is inactive; or determining to cause the sensor to transition to the power saving mode, in response to determining that a sensor reading of the sensor has been substantially constant for a predetermined time period.

[0110] FIG. 8 illustrates an example of a method for a sensor of a drill rig to transition to a power saving mode, according to a fourth aspect of the present disclosure.

[0111] At 801, the method may comprise obtaining, by the sensor, information on operational status of the drill rig.

[0112] At 802, the method may comprise determining, based on the operational status of the drill rig, to transition the sensor to a power saving mode.

[0113] At 803, the method may comprise transitioning the sensor the power saving mode.

[0114] According to an example embodiment of the fourth aspect, the method comprises: receive the at least one control signal or the at least one sensor signal over a wireless communication link.

[0115] According to an example embodiment of the second aspect, the method comprises: determining to cause the sensor to transition to the power saving mode, in response to determining, based on a status of the wireless communication link, that the drill rig is inactive; or determining to cause the sensor to transition to the power saving mode, in response to determining that a sensor reading of the sensor has been substantially constant for a predetermined time period.

[0116] According to a fifth aspect, an apparatus may comprise means for obtaining information on operational status of the drill rig; means for determining, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and means for causing the at least one sensor of the drill rig to transition to the power saving mode. The apparatus may comprise means for performing any example embodiment of the method of the third aspect.

[0117] According to a sixth aspect, a sensor may comprise means for obtaining information on operational status of the drill rig; means for determining, based on the operational status of the drill rig, to transition the sensor to a power saving mode; and means for transitioning the sensor the power saving mode. The sensor

may comprise means for performing any example embodiment of the method of the fourth aspect

[0118] According to a seventh aspect, a computer program, a computer program product, or a (non-transitory) computer-readable medium may comprise program instructions which, when executed by an apparatus, cause the apparatus at least to obtain information on operational status of the drill rig; determine, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and cause the at least one sensor of the drill rig to transition to the power saving mode. The computer program, the computer program product, or the (non-transitory) computer-readable medium may comprise program instructions which, when executed by an apparatus, cause the apparatus to perform any example embodiment of the method of the third aspect.

[0119] According to an eighth aspect, a computer program, a computer program product, or a (non-transitory) computer-readable medium may comprise program instructions which, when executed by a sensor, cause the sensor at least to: obtain information on operational status of the drill rig; determine, based on the operational status of the drill rig, to transition the sensor to a power saving mode; and transition the sensor the power saving mode. The computer program, the computer program product, or the (non-transitory) computer-readable medium may comprise program instructions which, when executed by an apparatus, cause the apparatus to perform any example embodiment of the method of the fourth aspect.

[0120] 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.

[0121] 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.

[0122] The steps or operations 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 scope of the subject matter described herein. Aspects of any of the example embodiments described above may be combined with aspects of any of the other example embodiments described to form further example embodiments without losing the effect sought.

[0123] 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.

[0124] As used herein, "at least one of the following: <a list of two or more elements>" and "at least one of <a list of two or more elements>" and similar wording, where the list of two or more elements are joined by "and" or "or", mean at least any one of the elements, or at least any two or more of the elements, or at least all the elements. Term "or" may be understood to also cover a case where both of the items separated by "or" are included. Hence, "or" may be understood as an inclusive "or" rather than an exclusive "or".

[0125] Although subjects may be referred to as 'first' or 'second' subjects, this does not necessarily indicate any order or importance of the subjects. Instead, such attributes may be used solely for the purpose of making a difference between subjects.

[0126] 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 exemplary 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 scope of this specification.

Claims

1. An apparatus for sensor control of a drill rig, the apparatus comprising:

at least one processor; and

at least one memory including computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:

obtain information on operational status of the drill rig;
determine, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and
cause the at least one sensor of the drill rig to transition to the power saving mode.

2. The apparatus according to claim 1, wherein the at least one memory and the computer program are code further configured to, with the at least one processor, cause the apparatus to:

determine the operational status of the drill rig based on at least one control signal provided by control circuitry of the drill rig.

3. The apparatus according to claim 2, wherein the at least one control signal is indicative of movement of a carrier of the drill rig or a position of the drill rig. 5
4. The apparatus according to claim 2 or 3, wherein the at least one control signal is indicative of: 10
 - the drill rig not being located at a planned drilling position, or
 - the drill rig being tramping.
5. The apparatus according to any of claims 2 to 4, wherein the at least one control signal is associated with powering a component of the drill rig or a tool of the drill rig. 15
6. The apparatus according to claim 5, wherein the at least one control signal is indicative of: 20
 - at least one actuator or hydraulic power pack of the drill rig associated with the at least one sensor being disabled; or
 - at least one actuator or hydraulic power pack of a boom of the drill rig being disabled, wherein the at least one sensor is located at the boom of the drill rig.
7. The apparatus according to any of claims 2 to 6, wherein the at least one control signal is indicative of: 25
 - a failure mode of the drill rig or at least one component of the drill rig associated with the at least one sensor,
 - at least one stabilizer jack of the drill rig not being positioned to ground, or
 - a motor of the drill rig not being running.
8. The apparatus according to any of claims 1 to 7, wherein the at least one memory and the computer program are code further configured to, with the at least one processor, cause the apparatus to: 30
 - receive at least one sensor signal from at least one other sensor of the drill rig and determine the operational status of the drill rig based on the at least one sensor signal.
9. The apparatus according to any of claims 4 to 8, wherein herein the at least one memory and the computer program are code further configured to, with the at least one processor, cause the apparatus to: 35
 - determine, based on the at least one control signal or the at least one sensor signal, the operational status of the drill rig as at least one of:

the drill rig not being located at the planned drilling position,
 the drill rig being tramping,
 the at least one actuator or hydraulic power pack of the drill rig being disabled,
 the at least one actuator or hydraulic power pack of the boom of the drill rig being disabled,
 the at least one stabilizer jack of the drill rig not being positioned to ground,
 the motor of the drill rig not being running,
 the drill rig or the component of the drill rig being in the failure mode; and
 determine to cause the at least one sensor of the drill rig to transition to the power saving mode, in response to determining the operational status of the drill rig as at least one of:

the drill rig not being located at the planned drilling position,
 the drill rig being tramping,
 the at least one actuator or hydraulic power pack of the drill rig being disabled,
 the at least one actuator hydraulic power pack of the boom of the drill rig being disabled,
 the at least one stabilizer jack of the drill rig not being positioned to ground,
 the motor of the drill rig not being running, or
 the drill rig or the component of the drill rig being in the failure mode.

10. The apparatus according to any of claims 1 to 9, wherein the at least one sensor comprises a boom angle sensor, and/or wherein the at least one sensor is a battery-powered sensor. 40
11. The apparatus according to any of claims 1 to 10, wherein the at least one memory and the computer program are code further configured to, with the at least one processor, cause the apparatus to: 45
 - transmit, to the at least one sensor, a request to transition to the power saving mode over a wireless communication link.
12. A sensor comprising the apparatus according to any of claims 1 to 10, wherein the at least one memory and the computer program are code configured to, with the at least one processor, cause the apparatus to transition the sensor to the power saving mode based on the operational status of the drill rig. 50
13. The sensor according to claim 12, wherein the at least one memory and the computer program are code further configured to, with the at least one processor, cause the apparatus to: 55

determine to cause the sensor to transition to the power saving mode, in response to determining,

based on a status of another wireless communication link, that the drill rig is inactive; or determine to cause the sensor to transition to the power saving mode, in response to determining that a sensor reading of the sensor has been substantially constant for a predetermined time period. 5

14. A method for sensor control of a drill rig, the method comprising: 10

obtaining information on operational status of the drill rig;
determining, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and 15
causing the at least one sensor of the drill rig to transition to the power saving mode.

15. A computer program comprising instructions which, 20
when executed by an apparatus, cause the apparatus at least to:

obtain information on operational status of the drill rig; 25
determine, based on the operational status of the drill rig, at least one sensor of the drill rig to be transitioned to a power saving mode; and
cause the at least one sensor of the drill rig to transition to the power saving mode. 30

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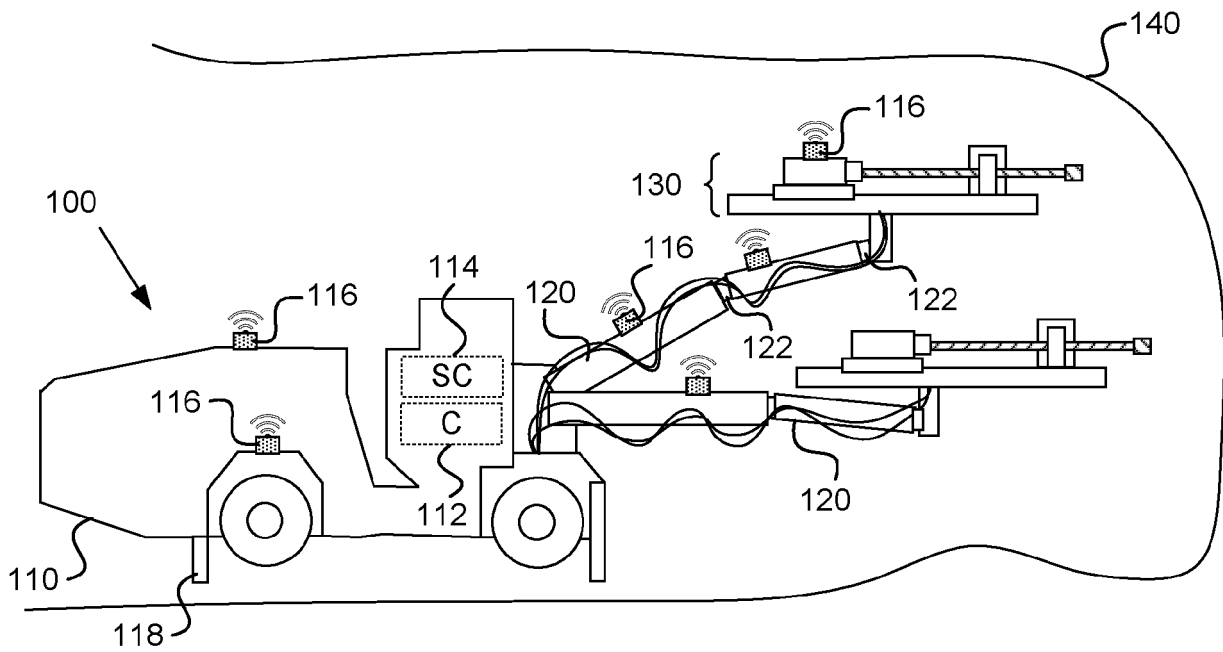


FIG. 1

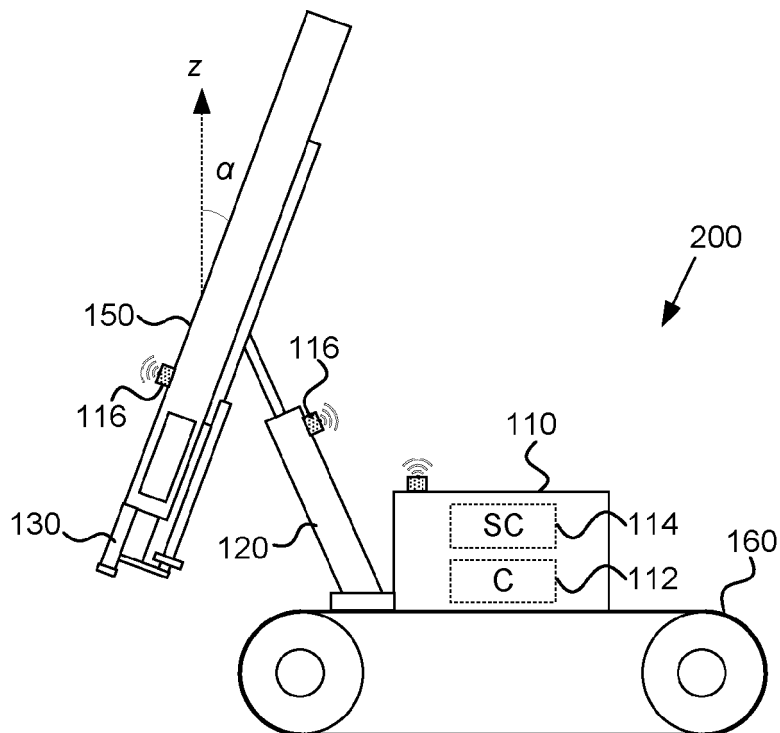


FIG. 2

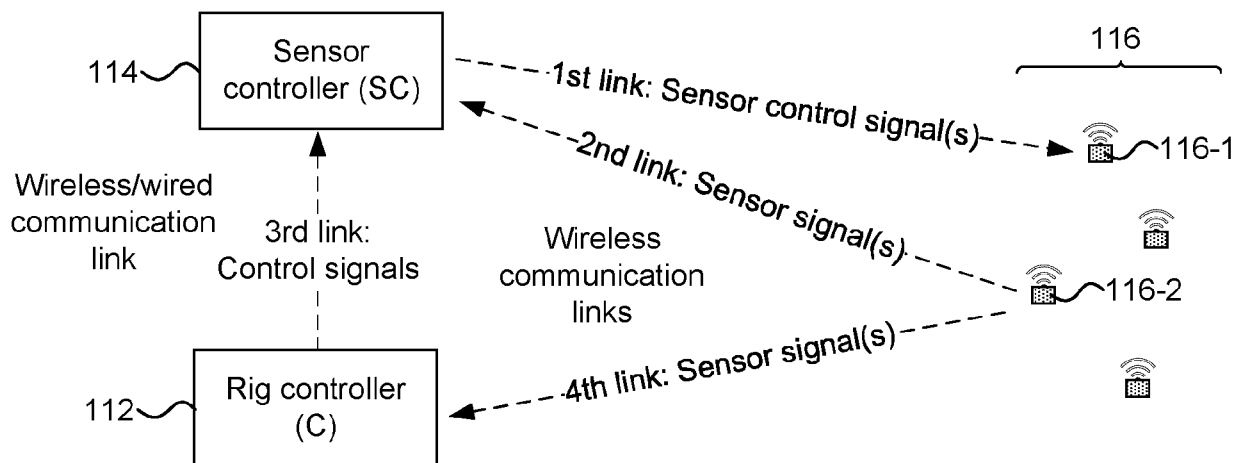


FIG. 3

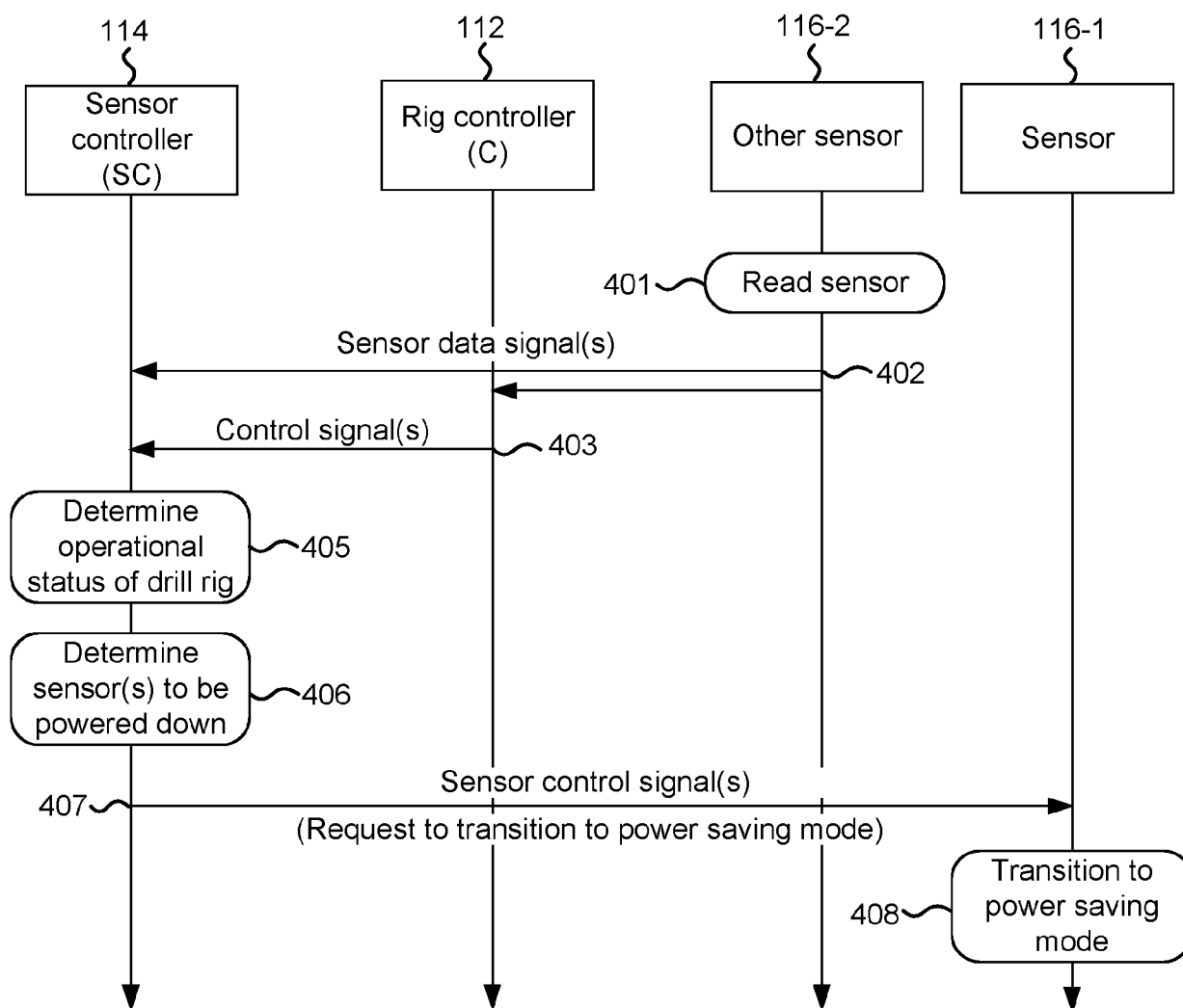


FIG. 4

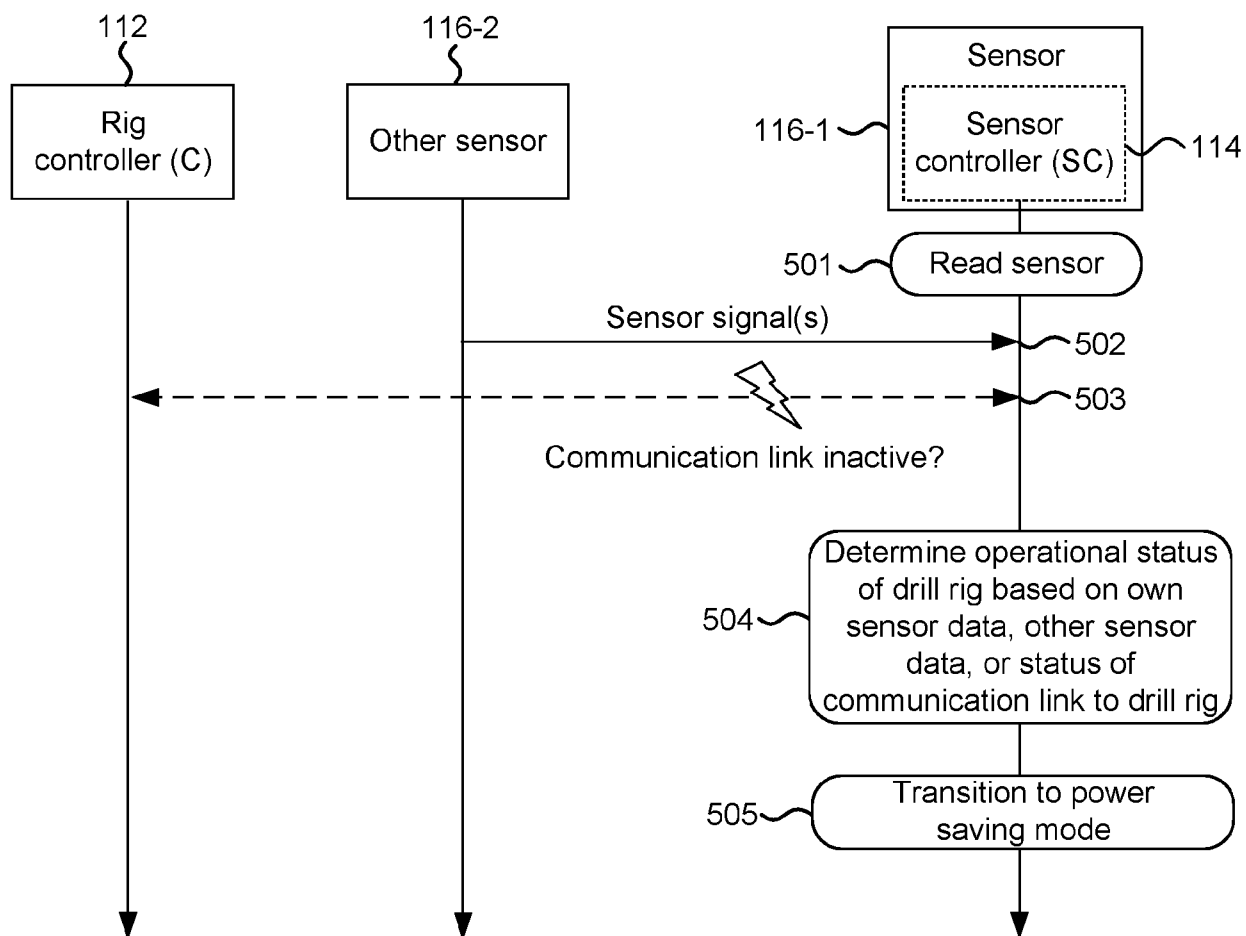


FIG. 5

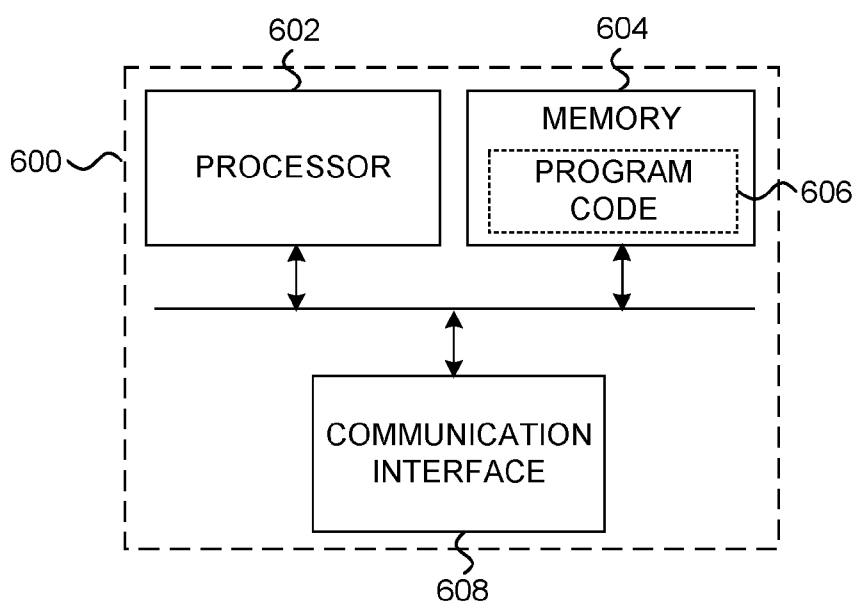


FIG. 6

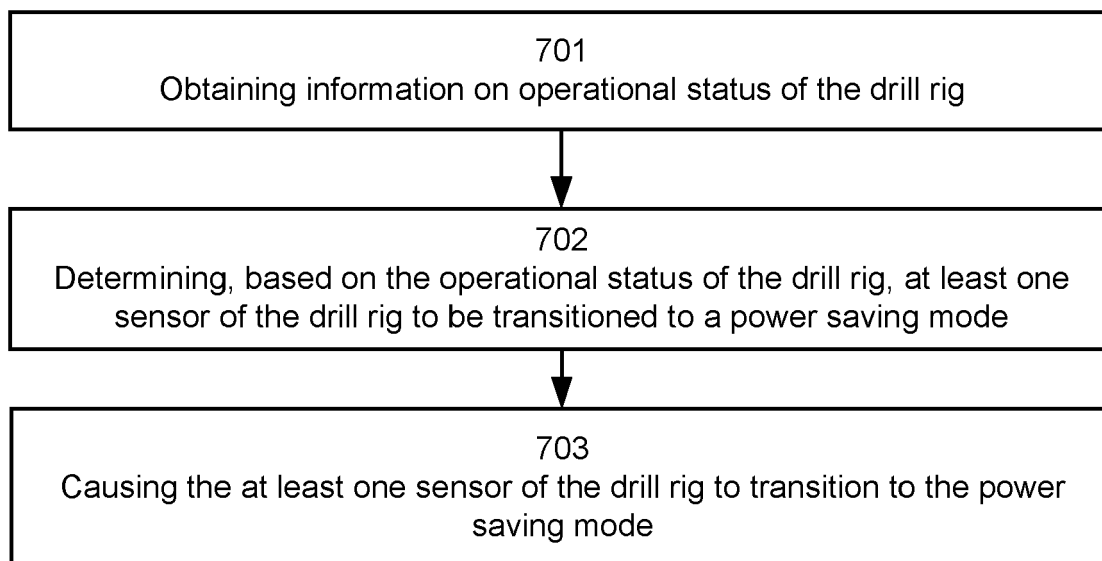


FIG. 7

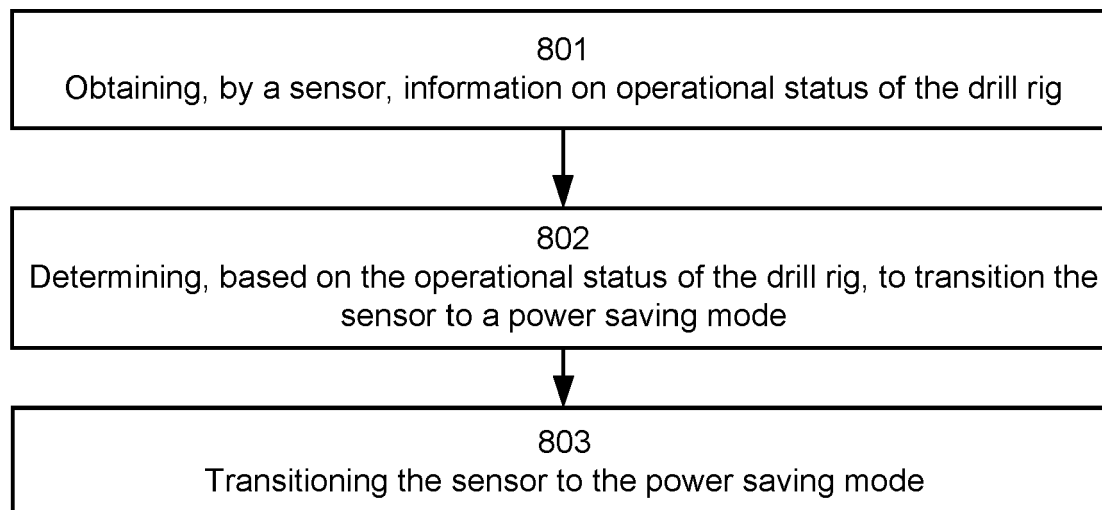


FIG. 8



EUROPEAN SEARCH REPORT

Application Number

EP 23 19 9732

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	US 2022/403735 A1 (CASWELL CRAIG A [US] ET AL) 22 December 2022 (2022-12-22)	1	INV.
Y	* paragraph [0008] - paragraph [0026]; figures 2,3 *	1-3,5,8,10-15	E21B7/04 E21B44/00 E21B47/13
A	-----	4,6,7,9	
Y	CN 114 616 607 A (FIRST SIGNAL AMERICAN INFORMATION ELECTRONIC LTD RESPONSIBILITY COMPAN) 10 June 2022 (2022-06-10)	1-3,5,8,10-15	
A	* abstract *	4,6,7,9	
A	-----		
A	US 11 319 797 B2 (CHARLES MACHINE WORKS [US]) 3 May 2022 (2022-05-03) * the whole document *	1-15	
A	-----		
A	US 8 836 534 B2 (FIELD GRANT ANDREW [AU]; SANDVIK INTELLECTUAL PROPERTY [SE]) 16 September 2014 (2014-09-16) * the whole document *	1-15	
A	-----		
A	US 11 092 000 B2 (METROL TECH LTD [GB]) 17 August 2021 (2021-08-17) * the whole document *	1-15	TECHNICAL FIELDS SEARCHED (IPC) E21B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 23 February 2024	Examiner Morrish, Susan
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 23 19 9732

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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23-02-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2022403735 A1	22-12-2022	CN 117546052 A	09-02-2024
		US 2022403735 A1	22-12-2022
		WO 2022271693 A1	29-12-2022
CN 114616607 A	10-06-2022	CN 114616607 A	10-06-2022
		EP 4032074 A1	27-07-2022
		US 2021082277 A1	18-03-2021
		US 2022230531 A1	21-07-2022
		WO 2021055711 A1	25-03-2021
US 11319797 B2	03-05-2022	NONE	
US 8836534 B2	16-09-2014	AU 2010245695 A1	12-01-2012
		CA 2761047 A1	11-11-2010
		CL 2011002795 A1	11-05-2012
		CN 102803642 A	28-11-2012
		US 2012056751 A1	08-03-2012
		WO 2010129944 A2	11-11-2010
		ZA 201108412 B	29-08-2012
US 11092000 B2	17-08-2021	AU 2017268922 A1	03-01-2019
		BR 112018074204 A2	06-03-2019
		CA 3024937 A1	30-11-2017
		CN 109477377 A	15-03-2019
		EA 201892752 A1	31-05-2019
		EP 3464814 A1	10-04-2019
		GB 2550868 A	06-12-2017
		MA 45110 A	10-04-2019
		MY 197380 A	14-06-2023
		SG 11201809971X A	28-12-2018
		US 2020318473 A1	08-10-2020
		WO 2017203295 A1	30-11-2017