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(54) **PROVISION OF FEEDBACK TO AN OPERATOR OF A MINING VEHICLE**

(57) According to an aspect, an apparatus for a mining vehicle may be configured to obtain, from at least one memory, mining vehicle reference performance data; obtain first machine control data associated with the mining vehicle, when an operator operates the mining vehicle; compare the first machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect at least one first deviation from the mining vehicle reference performance data; and provide a first feedback to the operator in response to detecting the at least one first deviation from the mining vehicle reference performance data.

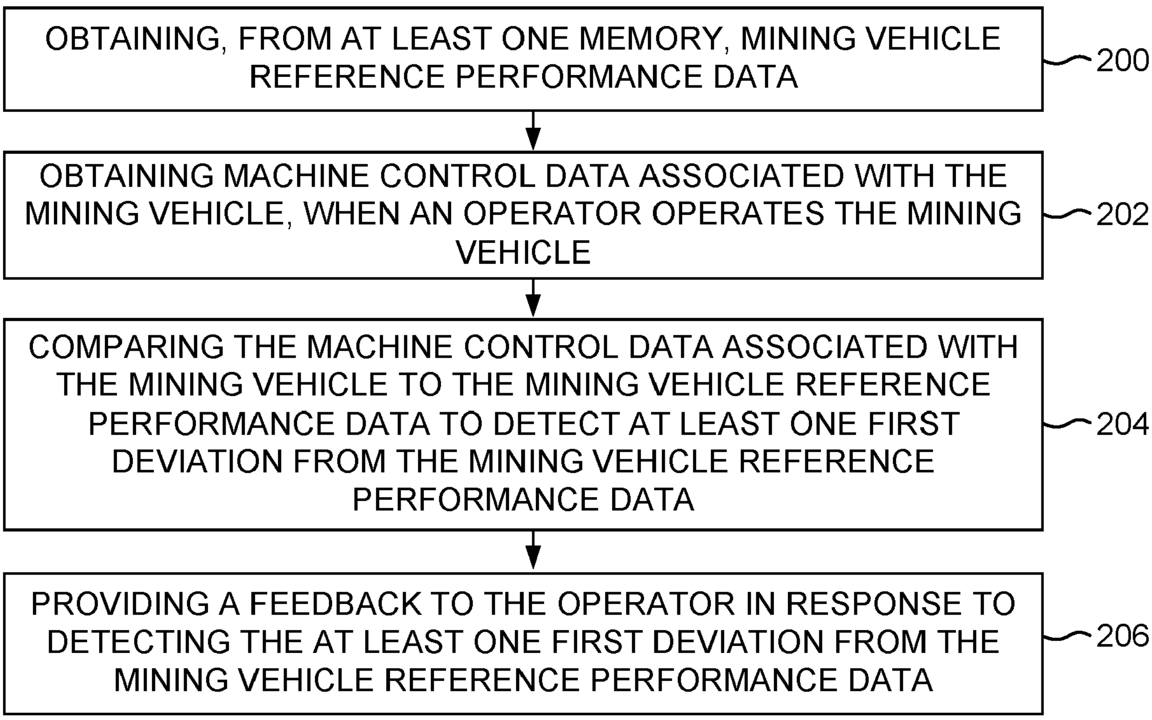

FIG. 2

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Description

TECHNICAL FIELD

[0001] Various example embodiments generally relate to the field of underground worksites and vehicles used therein. In particular, some example embodiments relate to a solution for providing feedback to an operator of a mining vehicle.

BACKGROUND

[0002] Mining or construction excavation worksites, such as underground hard rock or soft rock mines, use work machines, such as load and/or haul machines and drilling rigs, which may also be referred to generally as mining vehicles. A mining vehicle may be operated by a human operator.

[0003] When the operator operates the mining vehicle, the actions performed by the operator may not always be ideal in the working environment of the mining vehicle. For example, the operator may drive too fast in a mine or may wrongly apply brakes of the mining vehicle. The mining vehicle may collect performance data relating to the operator, and the performance data may then be post-processed, for example, after a shift, using, for example, cloud processing. After the post-processing, a performance evaluation of the operator may be established. However, as the performance evaluation is performed only afterwards, it may be difficult afterwards to link the operator's actions accurately, for example, to challenging sections in the mine, where the work is performed.

SUMMARY

[0004] 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.

[0005] Example embodiments may provide a solution that may enable provision of feedback to an operator of a mining vehicle in real-time or substantially in real-time.

[0006] According to a first aspect, there is provided an apparatus for a mining vehicle. The apparatus comprises at least one processor and at least one memory including computer program code. The at least one memory and the computer program code are configured to, with the at least one processor, cause the apparatus at least to: obtain, from the at least one memory, mining vehicle reference performance data; obtain first machine control data associated with the mining vehicle, when an operator operates the mining vehicle; compare the first machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect at least one first deviation from the mining vehicle reference performance data; and provide a first feedback to the operator in response to detecting the at least one first deviation from the mining vehicle reference performance data.

[0007] In an example embodiment of the first aspect, the at least one memory and the computer program code are further configured to with the at least one processor, cause the apparatus at least to: obtain identification information identifying the operator of the mining vehicle before the operator starts to operate the mining vehicle; associate the detected at least one deviation with the identification information to provide identified deviation data; and store the identified deviation data in the at least one memory.

[0008] In an example embodiment of the first aspect, the at least one memory and the computer program code are further configured to with the at least one processor, cause the apparatus at least to: read the identified deviation data from the at least one memory; obtain second machine control data associated with the mining vehicle, when the operator operates the mining vehicle; compare the second machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect at least one second deviation from the mining vehicle reference performance data; compare the detected at least one second deviation to the identified deviation data from the memory; and provide a second feedback to the operator based on the comparison.

[0009] In an example embodiment of the first aspect, the at least one memory and the computer program code are further configured to with the at least one processor, cause the apparatus at least to provide an overview associated with a time period to the operator based on the stored identified deviation data in the at least one memory.

[0010] In an example embodiment of the first aspect, the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus at least to transmit the identified deviation data stored in the at least one memory to a network entity.

[0011] In an example embodiment of the first aspect, the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus at least to: obtain, via a network connection, historical data associated with the operator operating the mining vehicle; and provide third feedback to the operator based on the stored identified deviation data and the historical data.

[0012] In an example embodiment of the first aspect, the first feedback, the second feedback, the third feedback and/or the overview comprises at least one of audio feedback and visual feedback.

[0013] In an example embodiment of the first aspect, the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus at least to: receive updated mining vehicle reference performance data via a network connection; and store the updated mining vehicle reference performance data in the at least one memory.

[0014] According to a second aspect, there is provided a mining vehicle comprising an apparatus according to the first aspect.

[0015] According to a third aspect, a method comprises obtaining, from at least one memory, mining vehicle reference performance data; obtaining first machine control data associated with the mining vehicle, when an operator operates the mining vehicle; comparing the first machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect at least one first deviation from the mining vehicle reference performance data; and providing a first feedback to the operator in response to detecting the at least one first deviation from the mining vehicle reference performance data.

[0016] In an example embodiment of the third aspect, the method further comprises obtaining identification information identifying the operator of the mining vehicle before the operator starts to operate the mining vehicle; associating the detected at least one deviation with the identification information to provide identified deviation data; and storing the identified deviation data in the at least one memory.

[0017] In an example embodiment of the third aspect, the method further comprises reading the identified deviation data from the at least one memory; obtaining second machine control data associated with the mining vehicle, when the operator operates the mining vehicle; comparing the second machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect at least one second deviation from the mining vehicle reference performance data; comparing the detected at least one second deviation to the identified deviation data from the memory; and providing a second feedback to the operator based on the comparison.

[0018] In an example embodiment of the third aspect, the method further comprises providing an overview associated with a time period to the operator based on the stored identified deviation data in the at least one memory.

[0019] In an example embodiment of the third aspect, the method further comprises transmitting the identified deviation data stored in the at least one memory to a network entity for further analysis.

[0020] In an example embodiment of the third aspect, the method further comprises obtaining, via a network connection, historical data associated with the operator operating the mining vehicle; and providing third feedback to the operator based on the stored identified deviation data and the historical data.

[0021] In an example embodiment of the third aspect, the first feedback, the second feedback, third feedback and/or the overview comprises at least one of audio feedback and visual feedback.

[0022] In an example embodiment of the third aspect, the method further comprises receiving updated mining vehicle reference performance data via a network connection; and storing the updated mining vehicle reference performance data in the at least one memory.

[0023] According to a fourth aspect, a computer program comprises instructions for causing an apparatus to carry out the method of the third aspect.

[0024] According to a fifth aspect, a non-transitory computer readable medium comprises a computer program comprising instructions for causing an apparatus to carry out the method of the third aspect.

[0025] Many of the attendant 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

[0026] 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 understand the example embodiments. In the drawings:

> **FIG. 1** illustrates an example of a system according to an example embodiment.
>
> **FIG. 2** illustrates an example of a method according to an example embodiment.
>
> **FIG. 3** illustrates an example of a method according to another example embodiment.
>
> **FIG. 4** illustrates an example of an apparatus configured to practice one or more example embodiments.

[0027] Like references are used to designate like parts in the accompanying drawings.

DETAILED DESCRIPTION

[0028] Reference will now be made in detail to example 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.

[0029] FIG. 1 illustrates an example of a system according to an example embodiment. A mining vehicle 100 may operate in a worksite, for example, an underground worksite or an aboveground worksite. The mining vehicle 100 may be any type of a mobile work machine suitable to be used in mine operations, such as lorries, dumpers, vans, mobile rock drilling or cutting rigs, mobile reinforcement machines, trucks, dumpers, and bucket loaders.

[0030] The mining vehicle 100 may comprise an apparatus 102 configured to provide real-time or substantially real-time performance evaluation of an operator of the mining vehicle 100. The apparatus 102 may be configured to provide feedback data to the operator using a feedback interface 104 or a feedback device, providing, for example, audio and/or visual feedback, for example, with a speaker and/or display device. In an example embodiment, the feedback device may be a tablet computer arranged in the mining vehicle 100. The apparatus 102 may be connected to a cloud system or systems 106 via a network connection. The cloud system 106 may be configured to provide to the apparatus 102 mining vehicle reference performance data providing information, for example, about approved performance of the operator of the mining vehicle, and the apparatus 102 may use this information when providing feedback with the feedback interface 104 to the operator. The feedback interface 104 may be an integral part of the apparatus 102. Alternatively, the feedback interface 104 may be an external device communicatively connected to the apparatus 102.

[0031] FIG. 2 illustrates an example of a method according to an example embodiment. The method may comprise a computer-implemented method implemented by an apparatus 102 configured for providing feedback, such as a controller workstation, a mobile unit, such as a mobile cellular device or other type of mobile communications device, a vehicle on-board control device, or other kind of appropriately configured data processing device in a mining vehicle.

[0032] At 200, the apparatus 102 may be configured to obtain, from a memory, mining vehicle reference performance data. The mining vehicle reference performance data may provide information, for example, about approved performance of operating the mining vehicle. The mining vehicle reference performance data may comprise, for example, one or more algorithms that have been determined based on measured data relating to operating a plurality of mining vehicles by a plurality of operators, and the algorithms may set a predefined performance level or levels for an operator of the mining vehicle 100. The mining vehicle reference performance data may comprise location dependent data, thus applicable only to predetermined locations in a mine. Additionally, or alternatively, the mining vehicle reference performance data may comprise universal data that applies to all mining vehicles of a specific model or type. The mining vehicle reference performance data may be associated with the operator (for example, comprising historical performance data associated with the operator, operational parameters of the vehicle associated with the operator, etc.) and/or with the mining vehicle itself. The term "approved performance" used herein may refer, for example, to one or more thresholds relating to one or more operating parameters of the mining vehicle.

[0033] The mining vehicle reference performance data may be stored in a memory of the apparatus 102 or a memory accessible by the apparatus 102. In an example embodiment, the mining vehicle reference performance data may be obtained and stored in the memory before an operator starts his/her shift. In another example embodiment, the mining vehicle reference performance data may be stored in the memory and updated when necessary by the cloud system 106.

[0034] At 202, the apparatus 102 may be configured to obtain machine control data associated with the mining vehicle, when an operator operates the mining vehicle. The machine control data may refer, for example, to data that the mining vehicle 100 provides when the operator operates the mining vehicle 100. For example, the machine control data may comprise a mining vehicle speed used by the operator at a plurality of points, various mining vehicle actions or operations performed by the operator, information relating to braking and/or accelerating of the mining vehicle, etc.

[0035] At 204, the apparatus 102 may be configured to compare the machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect at least one deviation from the mining vehicle reference performance data. The term "deviation" used herein may mean a deviation or a violation from a desired or expected behavior of the operator, when the operator operates the mining vehicle 100. For example, in a certain location or section in the mine the operator is allowed to use a maximum speed of 10 km/h. However, if the operator exceeds this maximum speed for more than 30 seconds, this may be considered as a "deviation" or "violation." Other examples of the deviation or violation may comprise, for example, at least one of the following:

- Loading downshift violation. For example, the operator approaches and hits a muck pile to fill a bucket with too high gear (for example, forward gear 2, although forward gear 1 should be used) and downshifts to a lower gear when there is still high traction against the muck pile (i.e., a lot of force going from the engine to the wheels).
- Braking violation. For example, the brake and throttle pedals are pressed at the same time and the tramming speed is > 5 km/h for more than 5 seconds.
- Extended braking violation. For example, the brakes are applied and the tramming speed is > 10kmh for more than 30 seconds.
- Underfeeding violation. For example, the feed and rotation pressures are too low (below 30 bars) compared to the percussion pressure (above 150 bars) .
- Overfeeding violation. For example, the rotation and feed pressures are too high (+150 bars) compared to the percussion pressure (+200 bars).

[0036] At 206, the apparatus 102 may be configured to provide feedback to the operator in response to detecting the at least one deviation from the mining vehicle reference performance data. The feedback may comprise audio and/or visual feedback. For example, a speaker may be controlled to inform the operator that "you have maintained the maximum allowed speed for too long" or "you are driving too fast" once the deviation or violation is detected. In another example embodiment, the deviation may also be a positive deviation indicating operator's good performance, and the feedback provided to the operator may comprise positive feedback. Thus, the operator of the mining vehicle 100 can be provided with real-time or substantially real-time feedback on his/her performance, thus enabling real-time operator competence development. In another example embodiment, additionally or alternatively, a display or a tablet computer arranged, for example, in the vicinity of the operator may be used to provide the feedback in an image form to the operator.

[0037] FIG. 3 illustrates an example of a method according to another example embodiment. The method may comprise a computer-implemented method implemented by an apparatus configured for providing feedback, such as a controller workstation, a mobile unit, such as a mobile cellular device or other type of mobile communications device, a vehicle on-board control device, or other kind of appropriately configured data processing device in a mining vehicle.

[0038] At 300, the apparatus 102 may be configured to obtain identification information identifying the operator of the mining vehicle 100 before the operator starts to operate the mining vehicle 100. The identification information may be obtained, for example, by a radio frequency identification (RFID) reader arranged in the mining vehicle 100 reading an RFID tag associated with the operator. In another example embodiment, the operator may be identified via other solutions, for example, via the feedback interface 104, an image recognition system, a fingerprint reader, a PIN code, etc. When the operator is identified, this enables all actions performed by the operator to be linked to the operator.

[0039] At 302, the apparatus 102 may be configured to obtain, from a memory, mining vehicle reference performance data. The mining vehicle reference performance data may provide information, for example, about approved performance of operating the mining vehicle. The mining vehicle reference performance data may comprise, for example, one or more algorithms that have been determined based on measured data relating to operating a plurality of mining vehicles by a plurality of operators, and the algorithms may set a predefined performance level or levels for an operator of the mining vehicle 100. The mining vehicle reference performance data may comprise location dependent data, thus applicable only to predetermined locations in a mine. Additionally, or alternatively, the mining vehicle reference performance data may comprise universal data that applies to all mining vehicles of a specific model or type. The mining vehicle reference performance data may be associated with the operator (for example, comprising historical performance data associated with the operator, operational parameters of the vehicle associated with the operator, etc.) and/or with the mining vehicle itself. The mining vehicle reference performance data may be stored in the memory of the apparatus 102 or a memory accessible by the apparatus 102. In an example embodiment, the mining vehicle reference performance data may be obtained and stored in the memory before an operator starts his/her shift. In another example embodiment, the mining vehicle reference performance data may be stored in the memory at any time and be updatable when necessary by the cloud system 106.

[0040] At 304, the apparatus 102 may be configured to obtain first machine control data associated with the mining vehicle 100, when the operator operates the mining vehicle 100. The first machine control data may refer, for example, to data that the mining vehicle 100 provides when the operator controls the mining vehicle 100. For example, the first machine control data may comprise a mining vehicle speed used by the operator, various mining vehicle actions or operations performed by the operator, etc.

[0041] At 306, the apparatus 102 may be configured to compare the first machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect 308 at least one first deviation from the mining vehicle reference performance data. The term "deviation" used herein may mean a deviation or a violation from a desired or expected behavior of the operator, when the operator operates the mining vehicle 100. For example, in a certain location or section in the mine the operator is allowed to use a maximum speed of 10 km/h. However, if the operator exceeds this maximum speed for more than 30 seconds, this may be considered as a "deviation" or "violation."

[0042] At 310, the apparatus 102 may be configured to provide feedback to the operator in response to detecting the at least one first deviation from the mining vehicle reference performance data. The feedback may comprise audio and/or visual feedback. For example, a speaker may be controlled to inform the operator that "you have maintained the maximum allowed speed for too long" or "you are driving too fast" once the deviation or violation is detected. Thus, the operator of the mining vehicle 100 can be provided with real-time or substantially real-time feedback about his/her performance. In another example embodiment, additionally or alternatively, a display or a tablet computer arranged, for example, in the vicinity of the operator may be used to provide the feedback to the operator. The steps 304-310 may be performed repeatedly to constantly monitor the performance of the operator and to provide real-time or substantially real-time feedback to the operator whenever necessary.

[0043] In an example embodiment, at 312, the apparatus 102 may be configured to associate the detected at least one deviation with the identification information to provide identified deviation data. At 314, the apparatus may be configured to store the identified deviation data in the memory. Thus, all the deviations or violations associated with the operator can be linked to a specific operator and can be used to prepare, for example, historical analysis associated with the operator. At 332, the apparatus 102 may be configured to transmit the identified deviation data stored in the memory to a network entity, for example, to a server or to the cloud system 106, for further analysis. The transmission may be performed, for example, periodically during an operator's shift or once at the end of the operator's shift.

[0044] At 316, at some point of time, the stored identified deviation data may be read from the memory. The reading operation may be performed, for example, when the operator starts a new, second shift, and steps 304-314 have been performed during a first shift. Before or after the step 316 the apparatus 102 may be configured to again obtain the identification information identifying the operator of the mining vehicle 100 before the operator starts to operate the mining vehicle 100 again.

[0045] At 318 the apparatus 102 may be configured to obtain second machine control data associated with the mining vehicle 100, when an operator operates the mining vehicle 100. The second machine control data may refer, for example, to data that the mining vehicle 100 stores when the operator controls the mining vehicle 100. For example, the second machine control data may comprise a mining vehicle speed used by the operator, various mining vehicle actions or operations performed by the operator, etc.

[0046] At 320, the apparatus 102 may be configured to compare the second machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect 322 at least one second deviation from the mining vehicle reference performance data. For example, in a certain location or section in the mine the operator is allowed to use a maximum speed of 10 km/h. However, if the operator exceeds this maximum speed for more than 30 seconds, this may be considered as a "deviation" or "violation."

[0047] At 324, the apparatus 102 may be configured compare the detected at least one second deviation to the identified deviation data read from the memory. In other words, the memory may be used to store short-term data about the operator's performance and this data may be used in evaluating the subsequent performance of the operator. For example, the identified deviation data stored in the memory may comprise information relating to a first shift of an operator. When the operator then starts a new shift, deviations or violations detected at 322 may be compared at 324 to the stored identified deviation data. This enables a solution in which at 326 second feedback may be provided to the operator based on the comparison. For example, the operator may be informed that "you have exceeded the maximum speed now two times more than during the first shift," etc.

[0048] As discussed earlier at steps 312 and 314, the detected deviations may be associated with the identification data relating to the operator and the identified deviation data may be stored in the memory and transmitted at 332 to the network entity, for example, to a server or to the cloud system 106, for further analysis.

[0049] In an example embodiment, the apparatus 102 may be configured to provide an overview associated with a time period to the operator based on the stored identified deviation data in the memory. The time period may be, for example, one shift. Thus, after each shift, the operator is able to see how he/she performed during the shift.

[0050] In an example embodiment, the apparatus 102 may be configured to obtain, via a network connection, historical data associated with the operator operating the mining vehicle, and provide feedback to the operator based on the stored identified deviation data and the historical data. For example, after each shift historical data may be requested, for example, from the cloud system 106 to enable comparison of the performance of the most recent shift with the historical data. Thus, the operator can immediately after the shift see how he/she performed compared to the historical data.

[0051] FIG. 4 illustrates an example of an apparatus 102 configured to practice one or more example embodiments. The apparatus 102 may comprise, for example, a server, a controller workstation, a mobile communications device, a vehicle on-board control device, or other kind of appropriately configured data processing device configured to implement functionality described herein. Although the apparatus 102 is illustrated as a single device, it is appreciated that, wherever applicable, functions of the apparatus 102 may be distributed to a plurality of devices.

[0052] The apparatus 102 may comprise at least one processor 400. The at least one processor 400 may comprise, for example, one or more of various processing devices or processor circuitry, such as, for example, a co-processor, 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, or the like.

[0053] The apparatus 102 may further comprise at least one memory 402. The at least one memory 402 may be configured to store, for example, computer program code or the like, for example, operating system software and application software, and mining vehicle reference performance data and deviation data associated with an operator of a mining vehicle. The at least one memory 402 may comprise one or more volatile memory devices, one or more nonvolatile memory devices, and/or a combination thereof. For example, the at least one memory 402 may be embodied as storage devices (such as hard disk drives, solid state drives, magnetic tapes, 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.).

[0054] The apparatus 102 may further comprise a communication interface 406 configured to enable the apparatus 102 to transmit and/or receive information to/from other devices, for example, the cloud system 106. In one example, the apparatus 102 may use the communication interface 406 to transmit or receive signaling information and data in accordance with at least one data communication or cellular communication protocol. The communication interface 406 may be configured to provide at least one wireless radio, such as, for example, a 3GPP mobile broadband connection (e.g., 3G, 4G, 5G, 6G, etc.), or a wired connection.

[0055] The apparatus 102 may further comprise a display 408 or an interface to which a display can be connected to. The apparatus 102 may further comprise an input device 410, for example, a keyboard, a mouse etc., for receiving user input.

[0056] When the apparatus 102 is configured to implement some functionality, some component and/or components of the apparatus 102, for example, the at least one processor 400 and/or the at least one memory 402, may be configured to implement this functionality. Furthermore, when the at least one processor 400 is configured to implement some functionality, this functionality may be implemented using the program code 404 comprised, for example, in the at least one memory 402.

[0057] 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 embodiment, the apparatus may comprise a processor or processor circuitry, for example, a microcontroller, configured by the program code when executed to execute the embodiments of the operations and functionality described herein. The program code 404 is provided as an example of instructions which, when executed by the at least one processor 400, cause performance of apparatus. 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).

[0058] The apparatus 102 may be configured to perform or cause performance of any aspect of the method(s) described herein. Further, a computer program may comprise instructions for causing, when executed, an apparatus to perform any aspect of the method(s) described herein. The computer program may be stored on a computer-readable medium. Further, the apparatus 102 may comprise means for performing any aspect of the method(s) described herein. In one example, the means comprises the at least one processor 400, the at least one memory 402 including the program code 404 (instructions) configured to, when executed by the at least one processor 400, cause the apparatus 102 to perform the method(s). In general, computer program instructions may be executed on means providing generic processing functions. 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 400. The means may comprise transmission and/or reception means, for example one or more 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.

[0059] Any range or device value given herein may be extended or altered without losing the effect sought. Also, 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 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 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] As used in this application, the term 'circuitry' may refer to one or more or all of the following: (a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and (b) combinations of hardware circuits and software, such as (as applicable) : (i) a combination of analog and/or digital hardware circuit(s) with software/firmware and (ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and (c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation. This definition of circuitry applies to all uses of this term in this application, including in any claims.

[0065] 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 a mining vehicle, 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, from the at least one memory, mining vehicle reference performance data;
        obtain first machine control data associated with the mining vehicle, when an operator operates the mining vehicle;
        compare the first machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect at least one first deviation from the mining vehicle reference performance data; and
        provide a first feedback to the operator in response to detecting the at least one first deviation from the mining vehicle reference performance data.

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

    obtain identification information identifying the operator of the mining vehicle before the operator starts to operate the mining vehicle;
    associate the detected at least one deviation with the identification information to provide identified deviation data; and
    store the identified deviation data in the at least one memory.

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

    read the identified deviation data from the at least one memory;
    obtain second machine control data associated with the mining vehicle, when the operator operates the mining vehicle;
    compare the second machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect at least one second deviation from the mining vehicle reference performance data;
    compare the detected at least one second deviation to the identified deviation data from the memory; and
    provide a second feedback to the operator based on the comparison.

4. The apparatus according to claim 2 or 3, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to:
    provide an overview associated with a time period to the operator based on the stored identified deviation data in the at least one memory.

5. The apparatus according to any one of claims 2 - 4, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to:
    transmit the identified deviation data stored in the at least one memory to a network entity.

6. The apparatus according to any one of claims 2 - 5, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the apparatus to:

    obtain, via a network connection, historical data associated with the operator operating the mining vehicle; and
    provide a third feedback to the operator based on the stored identified deviation data and the historical data.

7. The apparatus according to any one of claims 1 - 6, wherein the first feedback, the second feedback, the third feedback and/or the overview comprise at least one of audio feedback and visual feedback.

8. The apparatus according to any one of claims 1 - 7,

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

receive updated mining vehicle reference performance data via a network connection; and
store the updated mining vehicle reference performance data in the at least one memory.

9. A mining vehicle comprising an apparatus according to any one of claims 1 - 8.

10. A method for a mining vehicle, the method comprising:

obtaining, from at least one memory, mining vehicle reference performance data;
obtaining first machine control data associated with the mining vehicle, when an operator operates the mining vehicle;
comparing the first machine control data associated with the mining vehicle to the mining vehicle reference performance data to detect at least one first deviation from the mining vehicle reference performance data; and
providing a first feedback to the operator in response to detecting the at least one first deviation from the mining vehicle reference performance data.

11. A computer program comprising instructions for causing an apparatus to carry out the method of claim 10.

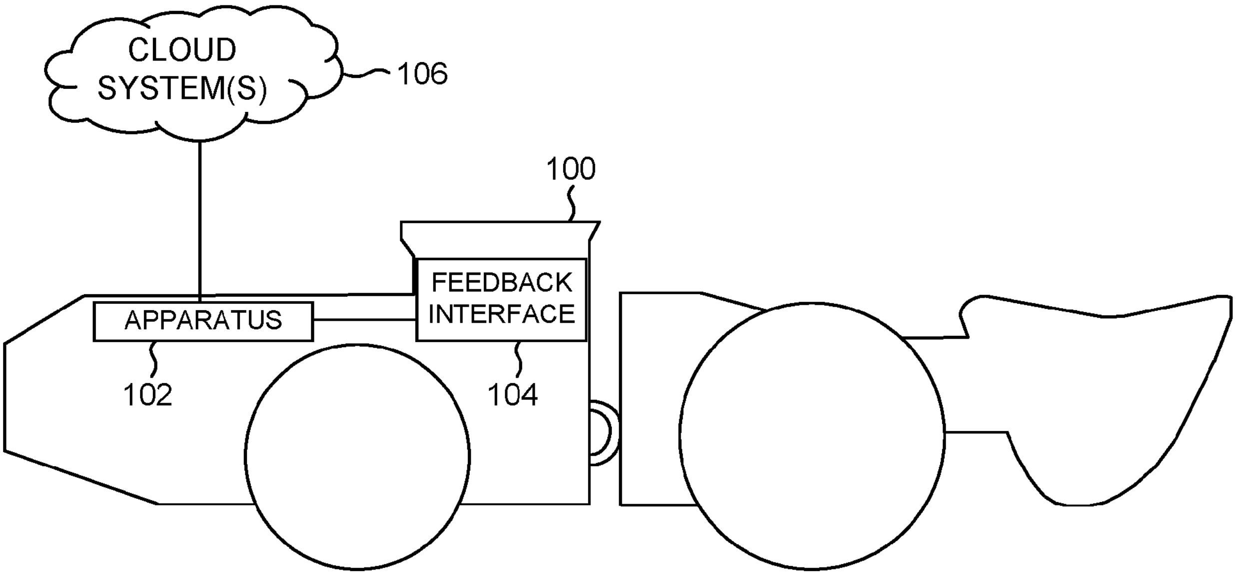

CLOUD
SYSTEM(S)
106
100
FEEDBACK
INTERFACE
APPARATUS
102
104

FIG. 1

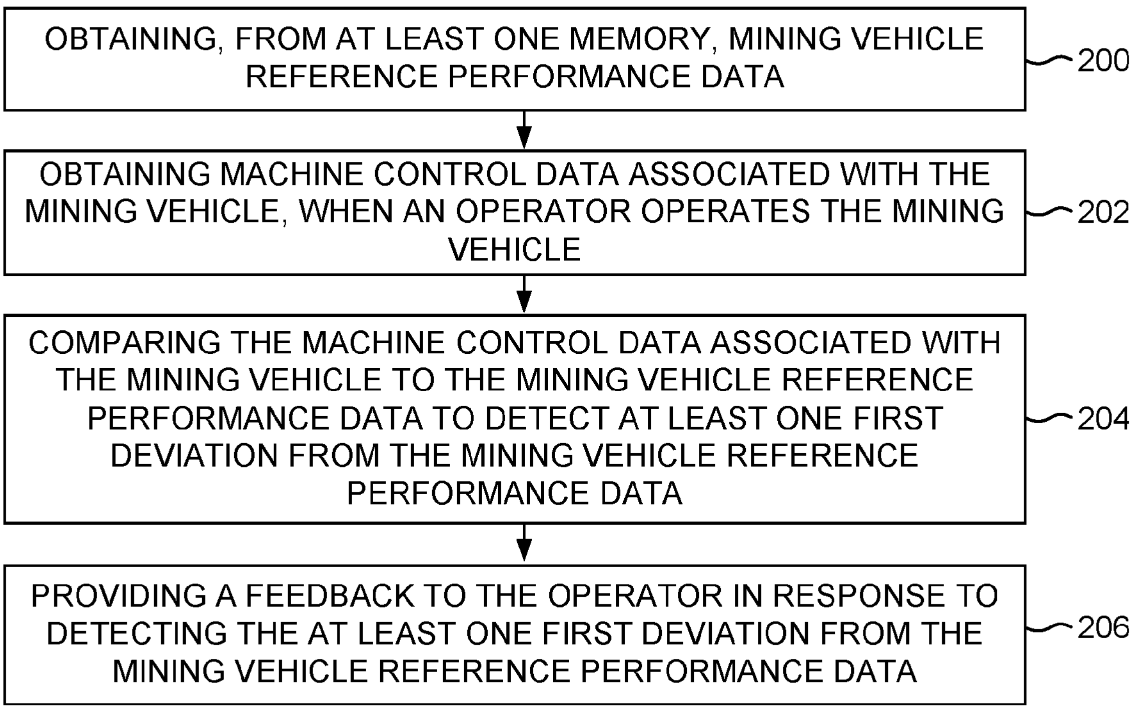

OBTAINING, FROM AT LEAST ONE MEMORY, MINING VEHICLE REFERENCE PERFORMANCE DATA
200
OBTAINING MACHINE CONTROL DATA ASSOCIATED WITH THE MINING VEHICLE, WHEN AN OPERATOR OPERATES THE MINING VEHICLE
202
COMPARING THE MACHINE CONTROL DATA ASSOCIATED WITH THE MINING VEHICLE TO THE MINING VEHICLE REFERENCE PERFORMANCE DATA TO DETECT AT LEAST ONE FIRST DEVIATION FROM THE MINING VEHICLE REFERENCE PERFORMANCE DATA
204
PROVIDING A FEEDBACK TO THE OPERATOR IN RESPONSE TO DETECTING THE AT LEAST ONE FIRST DEVIATION FROM THE MINING VEHICLE REFERENCE PERFORMANCE DATA
206

FIG. 2

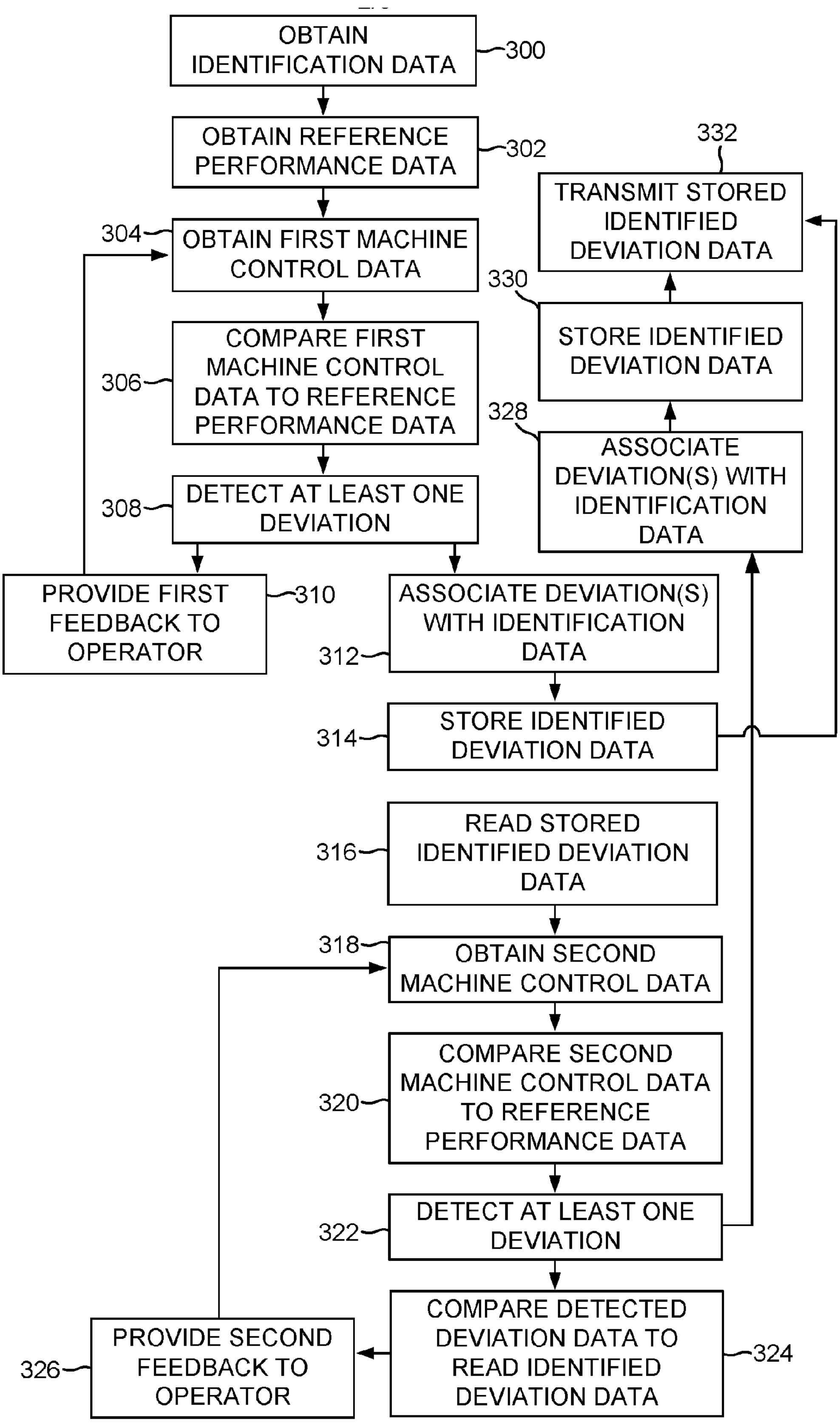
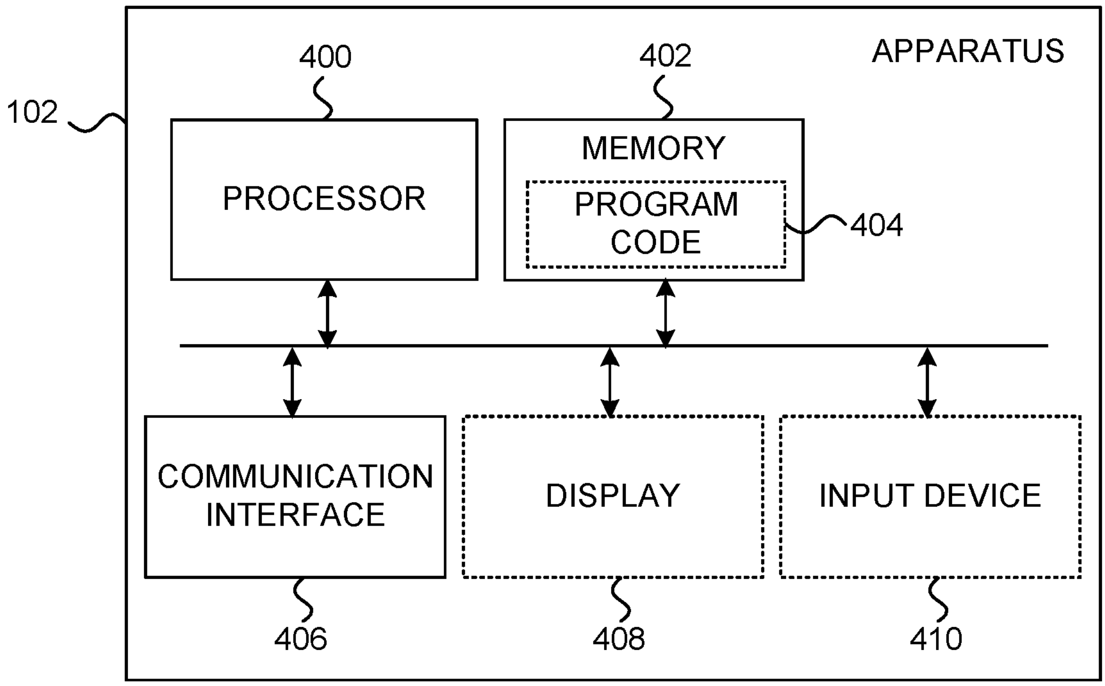

OBTAIN IDENTIFICATION DATA
300
OBTAIN REFERENCE PERFORMANCE DATA
302
304
OBTAIN FIRST MACHINE CONTROL DATA
306
COMPARE FIRST MACHINE CONTROL DATA TO REFERENCE PERFORMANCE DATA
308
DETECT AT LEAST ONE DEVIATION
PROVIDE FIRST FEEDBACK TO OPERATOR
310
ASSOCIATE DEVIATION(S) WITH IDENTIFICATION DATA
312
314
STORE IDENTIFIED DEVIATION DATA
316
READ STORED IDENTIFIED DEVIATION DATA
318
OBTAIN SECOND MACHINE CONTROL DATA
320
COMPARE SECOND MACHINE CONTROL DATA TO REFERENCE PERFORMANCE DATA
322
DETECT AT LEAST ONE DEVIATION
COMPARE DETECTED DEVIATION DATA TO READ IDENTIFIED DEVIATION DATA
324
326
PROVIDE SECOND FEEDBACK TO OPERATOR
332
TRANSMIT STORED IDENTIFIED DEVIATION DATA
330
STORE IDENTIFIED DEVIATION DATA
328
ASSOCIATE DEVIATION(S) WITH IDENTIFICATION DATA

FIG. 3



102
400
402
APPARATUS
PROCESSOR
MEMORY
PROGRAM CODE
404
COMMUNICATION INTERFACE
DISPLAY
INPUT DEVICE
406
408
410

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 23 15 4320

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X A	US 2015/004572 A1 (BOMER BRADLEY K [US] ET AL) 1 January 2015 (2015-01-01) * paragraphs [0020], [0023], [0045] - [0047]; claims 1,14,19; figures 1-4 *	1,2,4-11 3	INV. E02F9/26
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X	EP 4 079 976 A1 (KOMATSU MFG CO LTD [JP]) 26 October 2022 (2022-10-26) * paragraphs [0046], [0096]; figure 1 *	1,7,9-11	
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			TECHNICAL FIELDS SEARCHED (IPC)
			E02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 June 2023	Dreyer, Christoph

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CATEGORY OF CITED DOCUMENTS

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