



(51) International Patent Classification:

E02F 9/20 (2006.01) E02F 5/10 (2006.01)
E02F 9/26 (2006.01)

(21) International Application Number:

PCT/SE2023/050601

(22) International Filing Date:

15 June 2023 (15.06.2023)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: **EPIROC ROCK DRILLS AKTIEBOLAG**
[SE/SE]; SE-701 91 Örebro (SE).

(72) Inventors: **DAHL, Robert**; c/o Epiroc Rock Drills AB,
SE-701 91 Örebro (SE). **MALM, Patrik**; c/o Epiroc Rock
Drills AB, SE-701 91 Örebro (SE). **ERIKSSON, Lars M**;
c/o Epiroc Rock Drills AB, SE-701 91 Örebro (SE).

(74) Agent: **BERGENSTRÄHLE & PARTNERS AB**;
P.O.Box 17704, 118 93 Stockholm (SE).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG,
KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY,
MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA,
NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO,
RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH,
TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, CV,
GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST,
SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ,
RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ,

(54) Title: CABLE AND HOSE DETECTION SYSTEM

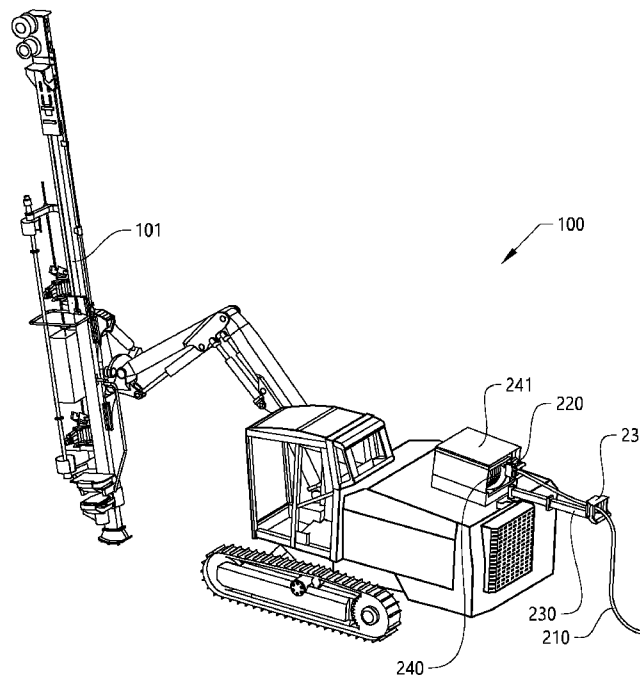


FIG. 1b

(57) Abstract: A method for tracking a cable or hose operatively connected at one end to a machine (100) and at another end remote from the machine (100), the machine (100) being communicatively connected to a control system arranged to provide a machine coordinate system. The method comprises collecting, by a sensor system (300) comprising at least one sensor (310) arranged on the machine (100), sensor data representing a space surrounding the machine (100), processing the collected sensor data to detect the cable/hose (210) in the collected sensor data, and assigning a plurality of coordinates to the detected cable/hose in the machine coordinate system to track the detected cable/hose relative to the machine (100).



DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT,
LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,
SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

CABLE AND HOSE DETECTION SYSTEM

Technical field

[0001] The present invention relates generally to detection and positioning of cables or hoses. Specifically, it relates to detection and positioning of cables or hoses attached to mining or construction machines.

Background art

[0002] For work in mining environments, a shift to electrically powered machines and vehicles is underway. This shift aims at least at improving the working environment as well as a step to lessen a dependence on fossil fuel. Furthermore, there are many additional positive effects of electrification. The working environment is not only cleaner from removing exhaust gases, but also having less noise. Removing exhaust gases furthermore lowers the demands on ventilation system capacity in underground environments.

[0003] One solution for facilitating the transition to electrical driven machines is connecting an electric cable to the machine, for example for transport, operation and for charging of on-board batteries. A cable may for example be needed when battery power is not sufficient for the heavy and energy intensive operations performed by mining or construction machines. The cable provides the machine with electricity during operation and therefore trails behind the machine in the mining environment.

[0004] The cable may be mounted on a cable reel, often located at the back of the machine. It may therefore be a problem for an on-board operator and/or for a remote operator to see the cable behind the machine. The need for an on-board operator to turn around in the seat, or even stand up in the machine cabin, to look for the cable presents an additional risk.

[0005] It may be additionally difficult to see the cable in bad light conditions or if the cable is covered with dirt, mud, snow or the like. As such, there is a risk of running over your own cable, or the cable of another machine. Cable overruns

lead to production stops and may furthermore be dangerous as high voltages run through the cables.

[0006] Apart from difficulties to see the cable, the position of the cable near the machine, but also the position of the cable on the ground, is furthermore difficult to predict. Uneven traveling surfaces and unplanned destinations mean that the cable may twist and turn and end up in unforeseen positions.

[0007] In prior art solutions, sensor systems are provided which measure a distance between the machine and the cable, to detect its position. Other prior art solutions comprise preventing certain movement patterns for mining or construction machines which are related to an increased risk of cable overrun, such as turning around its own shoulder to many times in sequence. In other prior art solutions for avoiding cable overruns, a cable guide is provided on the ground comprising holders for elevating the cable above ground. However, there remains a need to accurately determine the position of the cable and furthermore predict where the cable will be.

[0008] Corresponding issues are related to hoses connected to mining or construction machines, and trailing behind the machine to a liquid source, such as a source of pressurized gas. A hose may for example be a hydraulic hose connected to a remote hydraulic pump. Hydraulic systems are vital on mining or construction machines, for example for operating tools such as drills. The hose may also be attached to a source of hydrogen gas. Thus, running over such a hose leads to production stops and may be dangerous to people nearby.

[0009] Therefore, there is a need for solutions to accurately determine the position of the cable or hose and furthermore predict where the cable or hose will be.

Summary of invention

[0010] An object of the present invention is to overcome at least some of the problems outlined above.

[0011] This and other objects are achieved by means of a method for tracking a cable or hose operatively connected at one end to a machine for mining or construction, and at another end remote from the machine, the machine being communicatively connected to a control system arranged to provide a machine coordinate system. The method comprises collecting, by a sensor system comprising at least one sensor arranged on the machine, sensor data representing a space surrounding the machine, processing the collected sensor data to detect the cable/hose in the collected sensor data, and assigning a plurality of coordinates to the detected cable/hose in the machine coordinate system to track the detected cable/hose relative to the machine.

[0012] In some examples, the method is performed by means of artificial intelligence, optionally a machine learning method.

[0013] The artificial intelligence adds to the processing means the ability to “learn” i.e., progressively improve the performance from new data, without being explicitly programmed.

[0014] In some examples, the method comprises predicting a position of a part of the cable which is outside a detection range of the sensor system.

[0015] In some examples, the method comprises predicting a future position of the cable/hose.

[0016] In some examples, the method comprises displaying the detected cable/hose to an operator of the machine.

[0017] In some examples, the method comprises determining that there is a risk of damaging the cable/hose, wherein the risk is at least one of a risk of the machine driving over the cable/hose and a risk of the cable/hose being tangled.

[0018] In some examples, the method comprises transmitting a warning when there is a risk of damaging the cable/hose.

[0019] In some examples, the method comprises, when there is a risk of damaging the cable/hose, providing a suggested action to be executed by the machine to avoid damaging the cable/hose.

[0020] In some examples, the machine further comprises a cable/hose feeding system arranged on the machine being capable of controlling feeding of the cable/hose, and wherein collecting sensor data comprises collecting operating data from the cable/hose feeding system.

[0021] The cable feeding system has several advantages. One advantage is naturally that the cable can be wound and unwound when the machine travels in the mining environment and more or less cable is needed between the machine and the power source at the other end of the cable. Another advantage is to, by means of the guiding arm, keep the cable at a distance from the machine. Another advantage is to prevent the cable 210 from being tangled on the cable reel.

[0022] In some examples, the suggested action comprises controlling the cable/hose feeding system to prevent damaging the cable/hose.

[0023] In some examples, the sensor system comprises a vision system and the at least one sensor is an optical sensor and the sensor data comprises optical data, such as images or video, and wherein processing the collected sensor data comprises image analysis, optionally by mesh processing.

[0024] In some examples, processing the collected sensor data comprises utilizing a polygonal chain to track an outline of the cable/hose.

[0025] In a second aspect of the disclosure there is provided a tracking system for tracking a cable or hose operatively connected at one end to a machine for mining or construction and at another end remote from the machine, the machine being communicatively connected to a control system arranged to provide a machine coordinate system. The tracking system comprises a sensor system comprising at least one sensor arranged on the machine and arranged to collect sensor data representing a space surrounding the machine, a processing means, arranged to process the sensor data to detect the cable/hose in the data, and to

assign a plurality of coordinates to the detected cable/hose in the machine coordinate system to track the cable/hose relative to the machine.

[0026] In some examples, the sensor system comprises a vision system, and the at least one sensor is an optical sensor arranged to collect optical data, such as images or video.

[0027] In some examples, the machine comprises a cable/hose feeding system arranged on the machine being capable of controlling feeding of the cable/hose, and wherein the processing means is furthermore arranged to process operating data of the cable feeding system to detect the cable/hose in the collected sensor data.

[0028] In some examples, operating data relates to the feeding of the cable/hose and/or the position of the cable/hose in the cable feeding system.

[0029] In some examples, the cable/hose feeding system comprises a cable/hose reel and/or a cable/hose guide arm.

[0030] In some examples, the processing means comprises artificial intelligence, optionally a machine learning component.

[0031] The artificial intelligence adds to the processing means the ability to “learn” i.e., progressively improve the performance from new data, without being explicitly programmed.

[0032] In a third aspect of the invention there is provided a machine for mining or construction being operatively connected to a cable or hose, the cable/hose being connected remote from the machine at another end thereof, the machine being communicatively connected to a control system arranged to provide a machine coordinate system, wherein the machine comprises a sensor system comprising at least one sensor arranged on the machine and arranged to collect sensor data representing a space surrounding the machine, wherein the sensor system is comprised in a tracking system according to the disclosure.

[0033] In some examples, the cable/hose is a power cable attached at another end thereof to a power source.

[0034] In some examples, the cable/hose is attached at another end thereof to an outlet for a liquid.

[0035] In some examples, the machine comprises a cable/hose feeding system arranged on the machine being capable of controlling feeding of the cable/hose.

Brief description of drawings

[0036] The invention is now described, by way of example, with reference to the accompanying drawings, in which:

Figs. 1a and 1b display a mining machine exemplified as a drill rig.

Figs. 2a displays a mining machine exemplified as a loader.

Fig. 2b displays a mining machine exemplified as a mining truck.

Fig. 3 displays a cable/hose feeding system and a sensor system.

Fig. 4 displays a cable/hose feeding system and a sensor system.

Fig. 5 displays a method for tracking a cable/hose.

Fig. 6 displays a visualization of a method for detecting a cable/hose.

Fig. 7 displays a visualization of a method for detecting a cable/hose.

Fig. 8 displays a visualization of a method for detecting a cable/hose.

Fig. 9 displays a visualization of a method for detecting a cable/hose.

Detailed description

[0037] In the following, a detailed description of a method for tracking a cable or hose, a tracking system and a machine is provided. In the figures, like reference

numerals designate identical or corresponding elements throughout the figures. It will be appreciated that these figures are for illustration only and do not in any way restrict the scope of the present disclosure.

[0038] With reference to Fig. 1a and Fig. 1b there is displayed an exemplary embodiment of a machine 100. In Fig. 1a and Fig. 1b, the machine 100 is exemplified as a mining machine. When reference is made to a mining machine, this will be understood as a machine arranged to travel and operate in a mining environment. Thus, the machine may for example perform operations specifically related to mining, such as drilling, or other operations necessary for the operations in a mining environment, such as related to construction. The mining environment may be, but is not limited to, an underground mine, a surface mine, an open-pit mine. The mining environment may be an area adjacent to or in connection to a mine. As such, the mining environment could be seen as any area where the machine 100 may normally travel during operation. According to the embodiment in Fig. 1a and Fig. 1b, the machine 100 is exemplified as a drill rig 110. The drill rig 110 in Fig. 1a and Fig. 1b is mobile, meaning that it can travel in a mining environment for example for the purpose of drilling holes at various locations. The drill rig 110 in Fig. 1a and Fig. 1b travels by means of continuous tracks 102.

[0039] In one embodiment, the machine 100 is a construction machine. When reference is made to a construction machine, this will be understood as a machine arranged to travel and operate on a construction site, for example for construction of roads or powerplants.

[0040] In Fig. 1a and Fig. 1b, a cable is operatively connected to a back section of the machine 100. The cable 210 provides electrical energy to the machine 100. The energy supplied from the cable 210 is utilized by the machine 100 for example to travel in the mining environment, or for operating tools such as a drill 101 on the machine 100. As disclosed above, issues disclosed herein relating to electric cables such as the cable 210 seen in Fig. 1a and Fig. 1b, are also related to hoses (not seen in figures) operatively connected to, and trailing behind, the machine 100 to a liquid source. As such, when reference is made to cables and cable

related equipment, it will be understood that these solutions should be seen as equally applicable to hoses.

[0041] In the drill rig 110 displayed in Fig. 1b, a cable feeding system 200 of the drill rig 110 is visible. In Fig. 1b, the cable feeding system 200 is arranged on the drill rig 110. In other embodiments, the cable feeding system 200 may be arranged in another position on the machine 100, corresponding to the position where the cable 210 is operatively connected to the machine 100. In other embodiments, for example those displayed with reference to Fig. 1a, Fig. 2a and Fig. 2b, the cable feeding system 200 is integrated in the machine 100, meaning it is not visible from the outside.

[0042] The cable feeding system 200 generally comprises a cable guide 220 to steer the cable during winding and unwinding, a guiding arm 230 and optionally additional guiding means 231 arranged on the guiding arm 230. In one embodiment, the cable feeding system 200 further comprises a cable reel 240 onto which the cable 210 may be wound or unwound. In one embodiment, the cable guide 220 is arranged to position the cable 210 on the cable reel 240 during winding of the cable 210 thereon.

[0043] The cable reel 240 may be arranged in a housing 241. In one embodiment, the housing is integrated with the chassis of the machine 100. In one embodiment, the cable guide 220 is arranged attached to the housing. In one embodiment, the cable guide 220 is arranged attached to the machine 100. In one embodiment, the guiding arm 230 extends out from the housing. In one embodiment, one end of the guiding arm 230 is arranged attached to the housing. In one embodiment, one end of the guiding arm 230 is arranged attached to the machine 100.

[0044] During winding and unwinding of the cable 210 on the cable reel 240, the cable 210 passes through the cable guide 220. The cable guide 220 may be provided with rollers 221 between which the cable 210 passes. An embodiment of the rollers 221 is seen in more detail in Fig. 3 and Fig. 4. The rollers 221 may be cylindrical and arranged such that a lengthwise extension of each roller is

essentially perpendicular to a feeding direction of the cable 210. The rollers 221 may be in the shape of discs, or wheels. The mantle surface of the rollers 221 may be curved, for example such that they have a waist, to better guide the cable 210 between the rollers 221. In one embodiment, the cable 210 is wound onto the cable reel 240 by rotation of the cable reel 240. In one embodiment, the cable 210 is unwound from the cable reel 240 by rotation of the cable reel 240. To this end, the cable reel 240 may be provided with a motor to control the rotation of the cable reel 240. In one embodiment, the cable reel 240 may be provided with a resistance, or a brake, such that the cable 210 may be under tension between the cable guide 220 and the cable reel 240 during unwinding. Having tension between the cable guide 220 and the cable 210 on the cable reel 240, during winding and unwinding respectively, prevents tangling of the cable 210 on the cable reel 240.

[0045] The machine 100 is communicatively connected to a control system. In one embodiment, the control system is an on-board control system arranged in the machine 100. In one embodiment, the control system is a remote-control system arranged remote from the machine 100, such as at a control center or control room of the mining environment. In one embodiment, the control system is arranged to control navigation of the machine 100. In one embodiment, the control system is arranged to control navigation of a plurality of mining machines in the underground environment. Controlling navigation may for example comprise determining a position of the machine 100 and setting a travel route for the machine 100. In one embodiment, the control system is arranged to control operations of the machine 100 such as traction and operation of the tools of the machine 100. The control system may be operated by an operator, or autonomously operated, or a combination thereof.

[0046] The control system is arranged to provide a machine coordinate system. The machine coordinate system is specific to the machine 100 and provides coordinates for physical features of the machine 100, such that these features may be put in relation to each other. Physical features may be any physical part of the machine 100, such as, but not limited to, wheels/continuous tracks, tools or parts of the chassis. In one embodiment, the input data to the control system for

providing the machine coordinate system is provided by use of Real-Time Kinematic (RTK) receivers. RTK receivers are used to enhance the accuracy of the Global Navigation Satellite Systems (GNSS). The RTK technology may be referred to as RTK GNSS. By utilizing at least two RTK capable receivers, it is possible to measure a position of an object, such as a physical feature of a machine 100, with high accuracy, such as centimeter accuracy. In one embodiment, input data to the control system for providing the machine coordinate system is machine specific data relating to the machine 100, such as type of machine 100, size of the machine 100, what tools and features the machine 100 is equipped with. In one embodiment, input data to the control system for providing the machine coordinate system is odometry data, that is, data from motion sensors, such as angle sensors, arranged on the machine 100.

[0047] The machine 100 may be operated by an operator sitting inside the machine 100, operated by a remote operator, autonomously operated, or combinations thereof.

[0048] With reference to Fig. 2a, the machine 100 is exemplified as a loader 120. The loader 120 is arranged to load blasted rock into a mining truck at a blasting site. To this end, the loader 120 comprises a bucket 121 into which blasted rock may be loaded and subsequently emptied into e.g. a mining truck. With reference to Fig. 2b, the machine 100 is exemplified as a mining truck 130 arranged for transporting blasted rock from the blasting site and through the mining environment. In Fig. 2a and Fig. 2b, the cable 210 is operatively connected at the back of the loader 120, and the mining truck 130, respectively.

[0049] In Fig. 3a and Fig. 3b, there is displayed a section of the machine 100. In Fig. 3a and Fig. 3b, the cable 210 is operatively connected at the back of the machine 100, and as such, the cable feeding system 200 is arranged on a back section of the machine 100.

[0050] The disclosure is also related to a tracking system for the cable 210 operatively connected to the machine 100. The tracking system generally comprises a sensor system 300 and a processing means. The tracking system is

arranged to track a part of the cable 210 being in a space surrounding the machine 100. The space surrounding the machine should be understood as the space proximate, or in the vicinity of, the machine 100. In one embodiment, the space surrounding the machine 100 is defined as all points in a space surrounding the machine 100 which may conceivably be detected by the sensor system 300. Embodiments of the sensor system 300 can be seen in Fig. 3 and Fig. 4.

[0051] The sensor system 300 is arranged on the machine 100. The sensor system 300 comprises at least one sensor 310 arranged on the machine 100. The at least one sensor 310 is arranged to collect sensor data representing the space surrounding the machine 100. In one embodiment, the sensor system 300 comprises a plurality of the at least one sensor 310, wherein each of the plurality of sensors are arranged to collect sensor data representing different sections of the space surrounding the machine 100. In one embodiment, the sensor system 300 comprises more than one kind of sensor.

[0052] In Fig. 3 there is displayed two sensors of the at least one sensor 310, wherein one is arranged on the housing 241 and one is arranged on the guiding arm 230 of the cable feeding system 200. In Fig. 4, there is displayed two sensors of the at least one sensor 310, wherein both are arranged on the guiding arm 230 of the cable feeding system 200.

[0053] In one embodiment, the sensor system comprises a vision system. In one embodiment, the at least one sensor 310 is an optical sensor. In one embodiment, the at least one sensor 310 is arranged to collect optical sensor data such as images or video. In one embodiment, the at least one sensor 310 is a camera. In one embodiment, the at least one sensor 310 is a laser sensor. In one embodiment, the at least one sensor 310 is an electromagnetic sensor.

[0054] The processing means is arranged to process the sensor data collected by the sensor system 300. To this end, the processing means is communicatively connected to the sensor system 300. In one embodiment, the processing means is arranged in or on the machine 100. In one embodiment, the processing means is arranged remote from the machine 100. In one embodiment, the processing

means forms a part of the control system. In one embodiment, processing the collected sensor data comprises image analysis, optionally by mesh processing.

[0055] In one embodiment, data relating to operating parameters of the cable feeding system 200 is used as input data to the processing means, in addition to the collected sensor data. Operating parameters may be measured at the cable guide 220, such as if cable is being fed in or out through the cable guide 220 and/or how fast and/or how much cable has been fed. Operating parameters may relate to a position and/or angle of the guiding arm 230. Operating parameters may relate to how much cable is wound on the cable reel 240.

[0056] In one embodiment, the processing means further comprises artificial intelligence. In one embodiment, the processing means further comprises a machine learning component.

[0057] With reference to Fig. 5, a method 500 for tracking the cable 210 operatively connected to the machine 100 of the present disclosure will be described. The method 500 is preferably performed by the tracking system, and optionally by the control system. In Fig. 5, a dashed line represents optional method steps.

[0058] In step 501, sensor data representing the space surrounding the machine 100 is collected. The sensor data is collected by means of the sensor system 300. In one embodiment, collecting sensor data comprises recording images and or/video of the space surrounding the machine 100. In one embodiment, the images/video is shot and transmitted to the processing means in real time. In one embodiment, collecting sensor data comprises scanning the space surrounding the machine 100, such as by means of laser scanning.

[0059] In step 502, the collected sensor data is processed. The sensor data is input to and processed by the processing means. The sensor data is processed in order to detect the cable 210 in the collected sensor data. When reference is made to a detected cable, it should be understood as a virtual representation of

the cable 210, as detected by the processing means. Embodiments of the methods for data processing will now be described with reference to Figs. 6-9.

[0060] With reference to Figs. 6-9, there is displayed exemplary embodiments of methods for data processing for detecting the cable 210 in the collected sensor data. Specifically, methods for classifying the sensor data to detect the cable 210. In the exemplary embodiments displayed in Figs. 6-9, the at least one sensor 310 is a camera, the collected sensor data is an image, or video, for example a real-time video stream. The Figs. 6-9 display what should be understood as the collected sensor data, or a part thereof. Figs. 6-9 display an image collected by the at least one sensor 310 arranged on the guiding arm 230, wherein the at least one sensor is arranged directed away from the back of the machine 100. It will be understood that a video comprises a series of images and as such, when reference is made to an image, this may refer to a still picture or a video.

[0061] In Fig. 6, classifying is performed by means of Bezier curves. A Bezier curve is a parametric curve wherein a set of discrete control points, distributed between two endpoints, define a smooth, continuous curve. The detected cable may be divided, by the processing means, into several Bezier curves, or subcurves, each having two endpoints. In the figure, endpoints of subcurves can be seen as points at ends of tangent lines to the detected cable. In one embodiment, the center line following the shape of the detected cable in Fig. 6 is the output from the classifying and thus defines the detected cable.

[0062] In Fig. 7, classifying is performed by means of polygons for segmentation. In one embodiment, the polygons are interpreted, in a subsequent step, into segmentation masks. In one embodiment, the polygons are interpreted, in a subsequent step, into Bezier curves. In one embodiment, the polygons are interpreted, in a subsequent step, into segmentation masks and, in a further subsequent step, into Bezier curves. In one embodiment, the patterned surface in Fig. 7 is the output from the classifying and thus defines the detected cable.

[0063] In Fig. 8, classifying is performed by mesh processing. Mesh processing comprises dividing an image into a grid comprising squares, or applying a grid to

an image, and subsequently detecting which of the squares comprises at least one line which may be a section of the cable. In one embodiment, lines with low certainty are removed.

[0064] In Fig. 9 classifying is performed by placing points after which semantic segmentation masks are generated. In one embodiment, the lines connected by dots in Fig. 9 is the output from the classifying and thus defines the detected cable.

[0065] In one embodiment, the classifying utilizes a You Only Look Once (YOLO) approach, or a YOLO algorithm. The YOLO algorithm requires only a single forward propagation through a neural network to detect objects, or in other words, detecting the cable 210 in image is done in a single algorithm run. In one embodiment, the classifying utilizes a YOLinO approach, or a YOLinO algorithm. YOLinO is a development of YOLO, being specifically refined for the purpose of polyline detection.

[0066] In one embodiment, classification is performed by using Catmull-Rom splines.

[0067] In one embodiment, detecting the cable 210 comprises determining a cable direction, that is, which end of the cable 210 is operatively connected to the machine 100. In one embodiment, the cable direction is determined by utilizing a set of rules. In one embodiment, a rule of the set of rules relates to a thickness of the detected cable being larger at a certain position in the image. A determined cable direction is exemplified in Fig. 8, displayed as a set of consecutive arrows following the shape of the detected cable.

[0068] In one embodiment, the method further comprises utilizing a machine learning component capable of performing a machine learning method. The machine learning method generally comprises two steps, a training step and an inference step. During the training step, a machine learning algorithm is fed with a large amount of training data, such as previously collected sensor data from the sensor system, in which the cable 210 has been detected, such that both input

and output is known by the machine learning component. For example, a human may provide information relating to where the cable 210 is in the data, that is, classifying is performed with human assistance. During the inference step, the machine learning algorithm receives the collected sensor data in real time and detects the cable 210 in the collected sensor data in real time. That is, classifying is performed by the machine learning algorithm without human supervision.

[0069] Returning now to Fig. 5. In step 503, a plurality of coordinates is assigned to the detected cable. The coordinates are in the machine coordinate system, which provides that the position of the cable 210 in relation to the machine 100, or parts of the machine 100, can be determined. Step 503 may be performed by the processing means, optionally with data retrieved from or provided by the control system.

[0070] Step 504 comprises determining a risk of damaging the cable 210 is associated with the position of the cable. In one embodiment, the method comprises suggesting at least one action for the machine 100, such that the risk of damaging the cable 210 is prevented. In one embodiment, the method comprises preventing at least one action of the machine 100, such that the risk of damaging the cable 210 is prevented. The action may for example be related to a movement patten of the machine 100 such as turning or moving other physical features of the machine 100 such as tools. The action may for example be related to the cable feeding system 200, such as winding or unwinding of the cable 210 or moving the guiding arm 230. In one embodiment, the method comprises transmitting a warning to an operator of the machine 100, or a system for autonomous operation of the machine 100, when a risk of damaging the cable is associated with the position of the cable. One example of a risk of damaging the cable 210 can be seen in Fig. 4, where the cable is positioned close to the continuous track 102 and as such there is a risk of traveling over the cable 210.

[0071] In one embodiment, the method comprises determining if the cable 210 is operatively connected to the machine 100, or if it connected to another machine 100. As more than one machine 100 are operating at the same time in the mining

environment, there is a risk of driving over, or in other ways damaging, a cable of another machine 100. The determination of which machine 100 the cable 210 is operatively connected to, may for example be based on the position of the detected cable, or a size of the detected cable. The determination may also be based on current positions of the mining machines in the mining environment.

[0072] In one embodiment, the detected cable, and its position in relation to the machine 100, or parts of the machine 100, is displayed to an operator of the machine 100. In one embodiment, the detected cable is displayed together with a real time video from the sensor system 300, such that the detected cable is clearly visible in the real time video. In one embodiment, the virtual representation is displayed on a display arranged in the machine 100. In one embodiment, the virtual representation is displayed on a portable display, such as a smartphone or a tablet. In one embodiment, the virtual representation is displayed on a computer screen, such as a computer screen remote from the machine 100.

[0073] In one embodiment, the detected cable, and its position in relation to the machine 100, or parts of the machine 100, is utilized by a system for autonomous operation of the machine 100.

[0074] In one embodiment, the method further comprises predicting a position of a part of the cable 210 which is not visible to the sensor system 300, or in other words, outside a detection range of the sensor system 300. In one embodiment, the method comprises assigning coordinates to the part of the cable 210 which is not visible to the sensor system 300 such that the position of the cable 210 in relation to the machine 100, or parts of the machine 100, can be determined. In one embodiment, the prediction is made by extrapolating the plurality of coordinates between collected sensor data from a first sensor and a second sensor, such that the extrapolated coordinates are in a space surrounding the machine 100 which is not part of the collated sensor data. In one embodiment, the prediction is made based on input data from operating parameters from the cable feeding system 200, odometry data, input from an operator, or other input data known to the skilled person.

[0075] In one embodiment, the method further comprises predicting a future position of the cable 210. The future position of the cable 210 is based on the processed sensor data, optionally in combination with data relating to for example a planned operation of the machine 100, odometry data, input from an operator, or other input data known to the skilled person. In one embodiment, the method comprises determining that there is risk of damaging the cable 210 when it is in the future position. In one embodiment, the method comprises predicting a plurality of potential future positions of the cable 210, and determining for which of said future positions there is a risk of damaging the cable 210. In one embodiment, the method comprises suggesting at least one action for the machine 100, such that a risk of damaging the cable 210 is prevented. In one embodiment, the method comprises preventing at least one action of the machine 100, such that a risk of damaging the cable 210 is prevented. In one embodiment, the method comprises transmitting a warning to an operator of the machine 100, or a system for autonomous operation of the machine 100, when a risk of damaging the cable 210 is associated with the position of the cable 210.

- - -

CLAIMS

1. A method for tracking a cable or hose operatively connected at one end to a machine (100) for mining or construction, and at another end remote from the machine (100), the machine (100) being communicatively connected to a control system arranged to provide a machine coordinate system, wherein the method comprises:

collecting, by a sensor system (300) comprising at least one sensor (310) arranged on the machine (100), sensor data representing a space surrounding the machine (100),

processing the collected sensor data to detect the cable/hose (210) in the collected sensor data, and

assigning a plurality of coordinates to the detected cable/hose in the machine coordinate system to track the detected cable/hose relative to the machine (100).

2. The method according to claim 1, being performed by means of artificial intelligence, optionally a machine learning method.

3. The method according to claim 1 or 2, further comprising:
predicting a position of a part of the cable which is outside a detection range of the sensor system (300).

4. The method according to any one of the preceding claims, further comprising predicting a future position of the cable/hose (210).

5. The method according to any one of the preceding claims, further comprising displaying the detected cable/hose to an operator of the machine (100).

6. The method according to any one of the preceding claims, further comprising determining that there is a risk of damaging the cable/hose (210),

wherein the risk is at least one of a risk of the machine (100) driving over the cable/hose (210) and a risk of the cable/hose (210) being tangled.

7. The method according to claim 6, further comprising transmitting a warning when there is a risk of damaging the cable/hose (210).

8. The method according to any one of claims 6-7, further comprising, when there is a risk of damaging the cable/hose (210), providing a suggested action to be executed by the machine (100) to avoid damaging the cable/hose (210).

9. The method according to any one of the preceding claims, wherein the machine (100) further comprises a cable/hose feeding system (200) arranged on the machine (100) being capable of controlling feeding of the cable/hose (210), and wherein collecting sensor data comprises collecting operating data from the cable/hose feeding system (200).

10. The method according to claim 9 when depending on claim 8, wherein the suggested action comprises controlling the cable/hose feeding system (200) to prevent damaging the cable/hose (210).

11. The method according to any one of the preceding claims, wherein the sensor system (300) comprises a vision system and the at least one sensor is an optical sensor, the sensor data comprises optical data, such as images or video, and wherein

processing the collected sensor data comprises image analysis, optionally by mesh processing.

12. The method according to any one of the preceding claims, wherein processing the collected sensor data comprises utilizing a polygonal chain to track an outline of the cable/hose (210).

13. A tracking system for tracking a cable or hose operatively connected at one end to a machine (100) for mining or construction and at another end remote from the machine (100), the machine (100) being communicatively connected to a control system arranged to provide a machine coordinate system, the tracking

system comprising:

a sensor system (300) comprising at least one sensor (310) arranged on the machine (100) and arranged to collect sensor data representing a space surrounding the machine (100),

a processing means, arranged to process the sensor data to detect the cable/hose (210) in the data, and to assign a plurality of coordinates to the detected cable/hose in the machine coordinate system to track the cable/hose (210) relative to the machine (100).

14. The tracking system according to claim 13, wherein sensor system (300) comprises a vision system and wherein the at least one sensor (310) is an optical sensor arranged to collect optical data, such as images or video.

15. The tracking system according to claim 13 or 14, wherein the machine (100) comprises a cable/hose feeding system (200) arranged on the machine (100) being capable of controlling feeding of the cable/hose (210), and wherein the processing means is furthermore arranged to process operating data of the cable feeding system to detect the cable/hose (210) in the collected sensor data.

16. The tracking system according to claim 15, wherein operating data relates to the feeding of the cable/hose (210) and/or the position of the cable/hose (210) in the cable/hose feeding system (200).

17. The tracking system according to any one of claims 15-16, wherein the cable/hose feeding system (200) comprises a cable/hose reel (240) and/or a cable/hose guide arm (230).

18. The tracking system according to any one of claims 13-17, wherein the processing means comprises artificial intelligence, optionally a machine learning component.

19. A machine (100) for mining or construction being operatively connected to a cable or hose, the cable/hose (210) being connected remote from the machine (100) at another end thereof, the machine (100) being communicatively connected to a control system arranged to provide a machine coordinate system,

wherein the machine (100) comprises a sensor system (300) comprising at least one sensor (310) arranged on the machine (100) and arranged to collect sensor data representing a space surrounding the machine (100), wherein the sensor system (300) is comprised in a tracking system according to any one of claims 13-18.

20. The machine (100) according to claim 19, wherein the cable (210) is a power cable attached at another end thereof to a power source.

21. The machine (100) according to claim 19, wherein the hose (210) is attached at another end thereof to an outlet for a liquid.

22. The machine (100) according to any one of claims 19-21, wherein the machine (100) comprises a cable/hose feeding system (200) arranged on the machine (100) being capable of controlling feeding of the cable/hose (210).

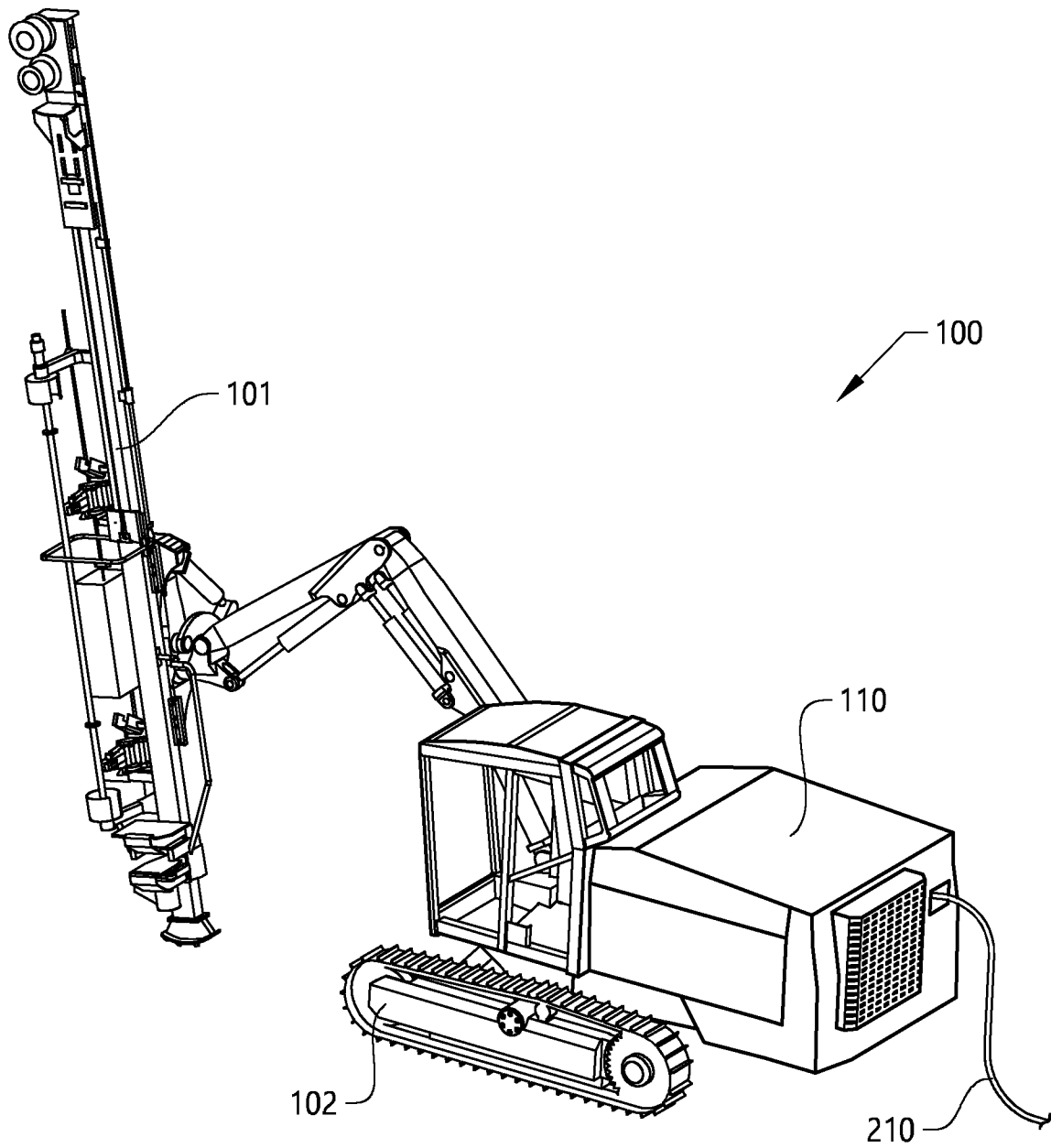


FIG. 1a

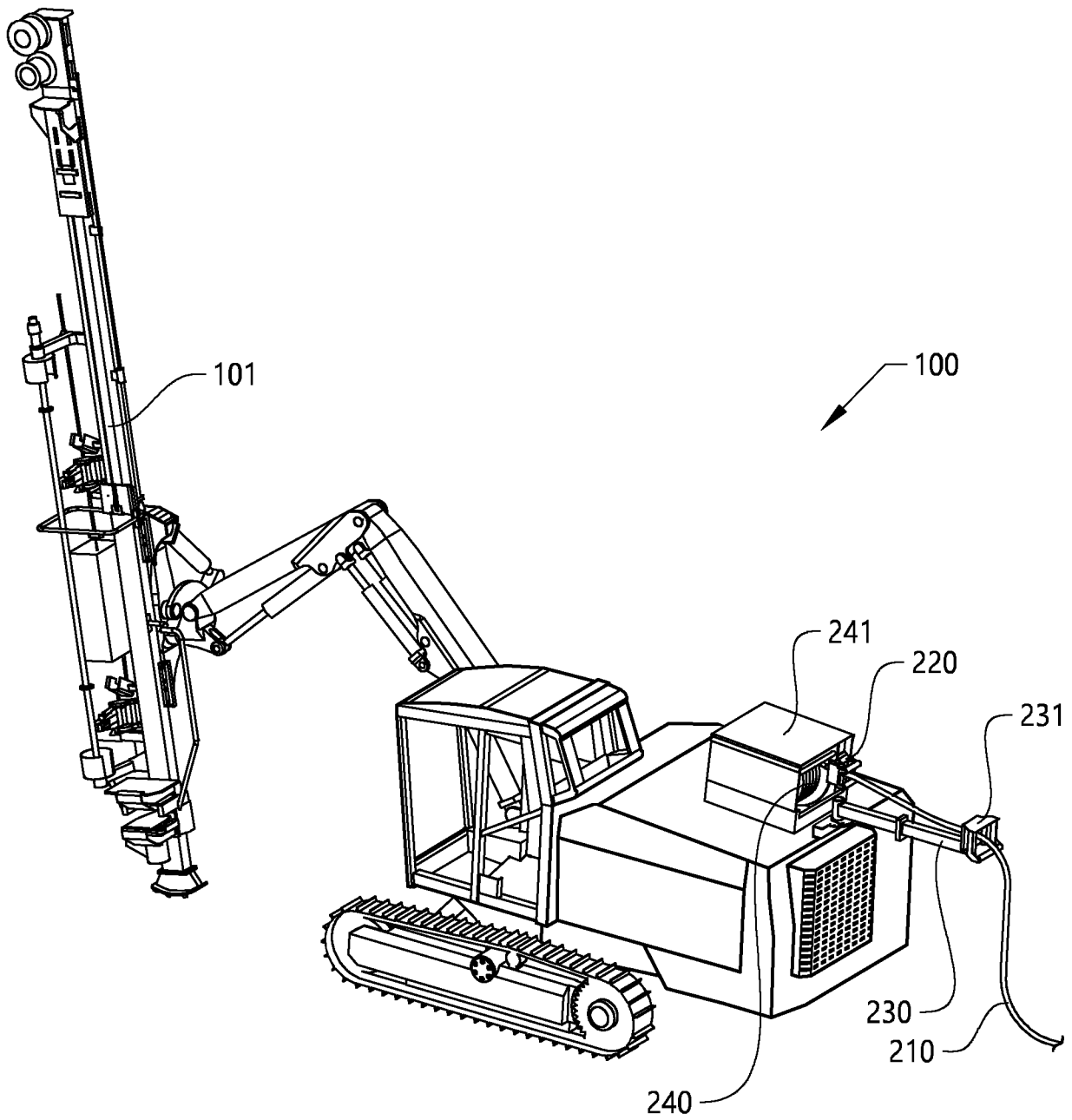


FIG. 1b

3/9

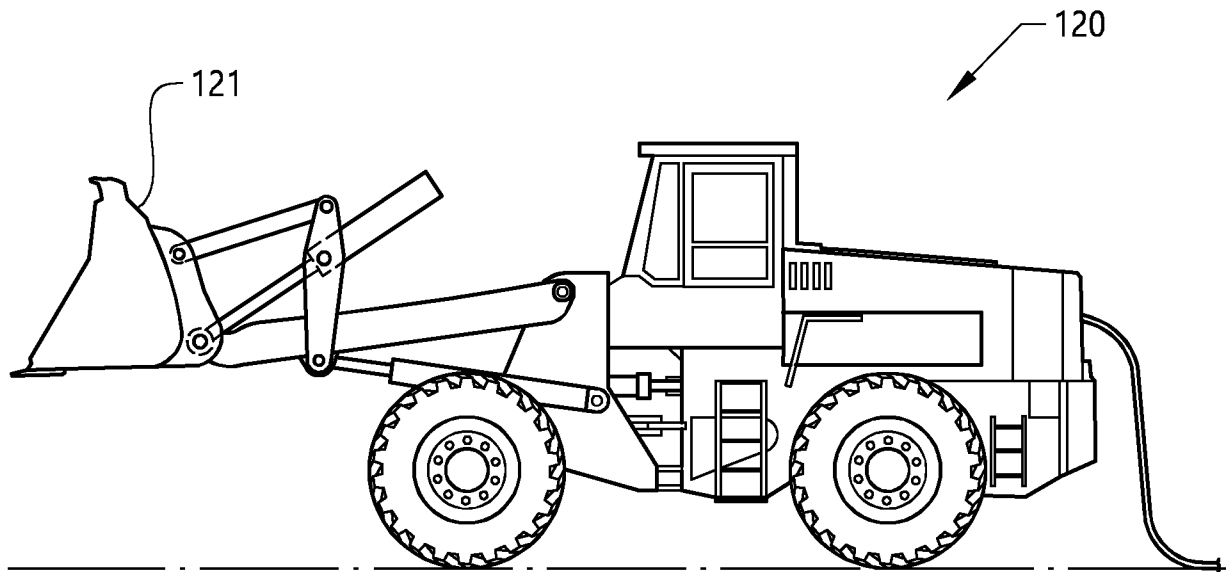


FIG. 2a

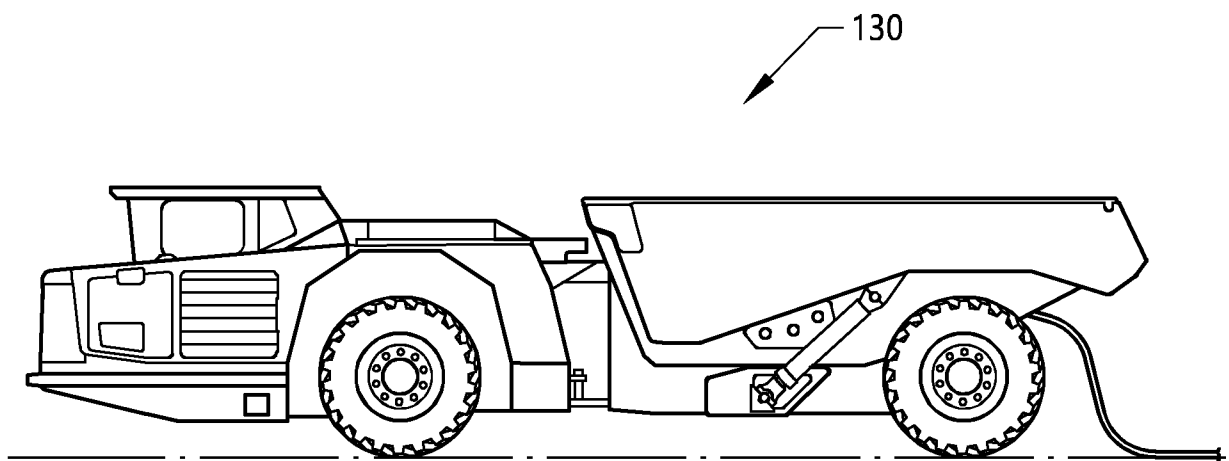


FIG. 2b

4/9

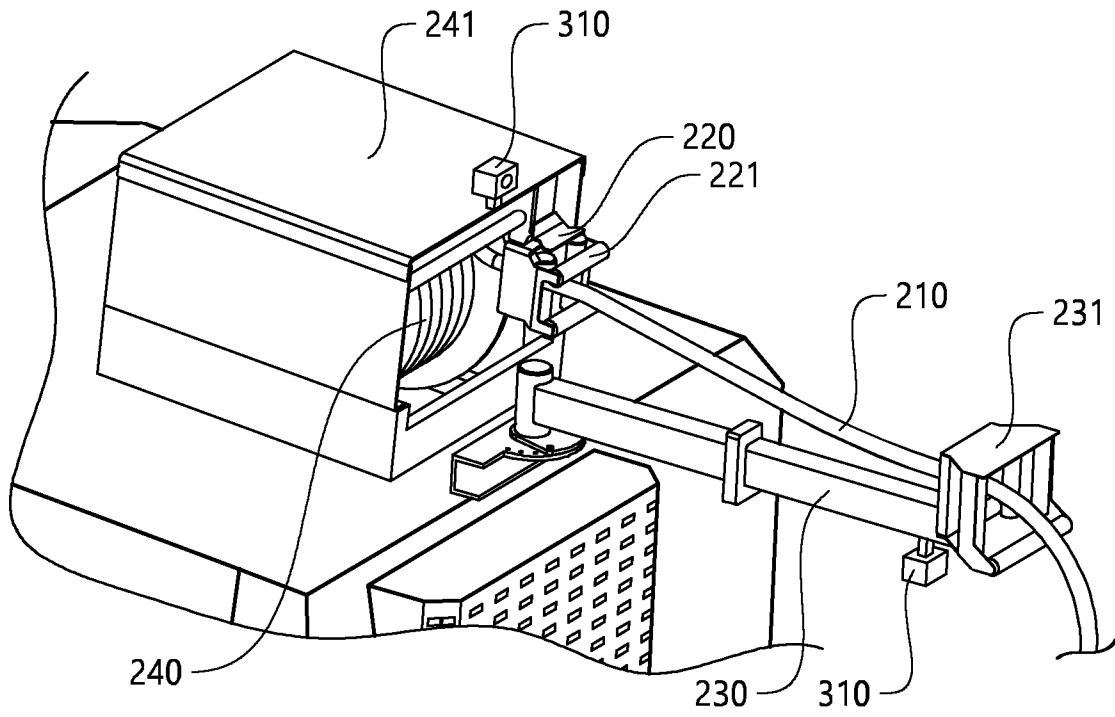


FIG. 3

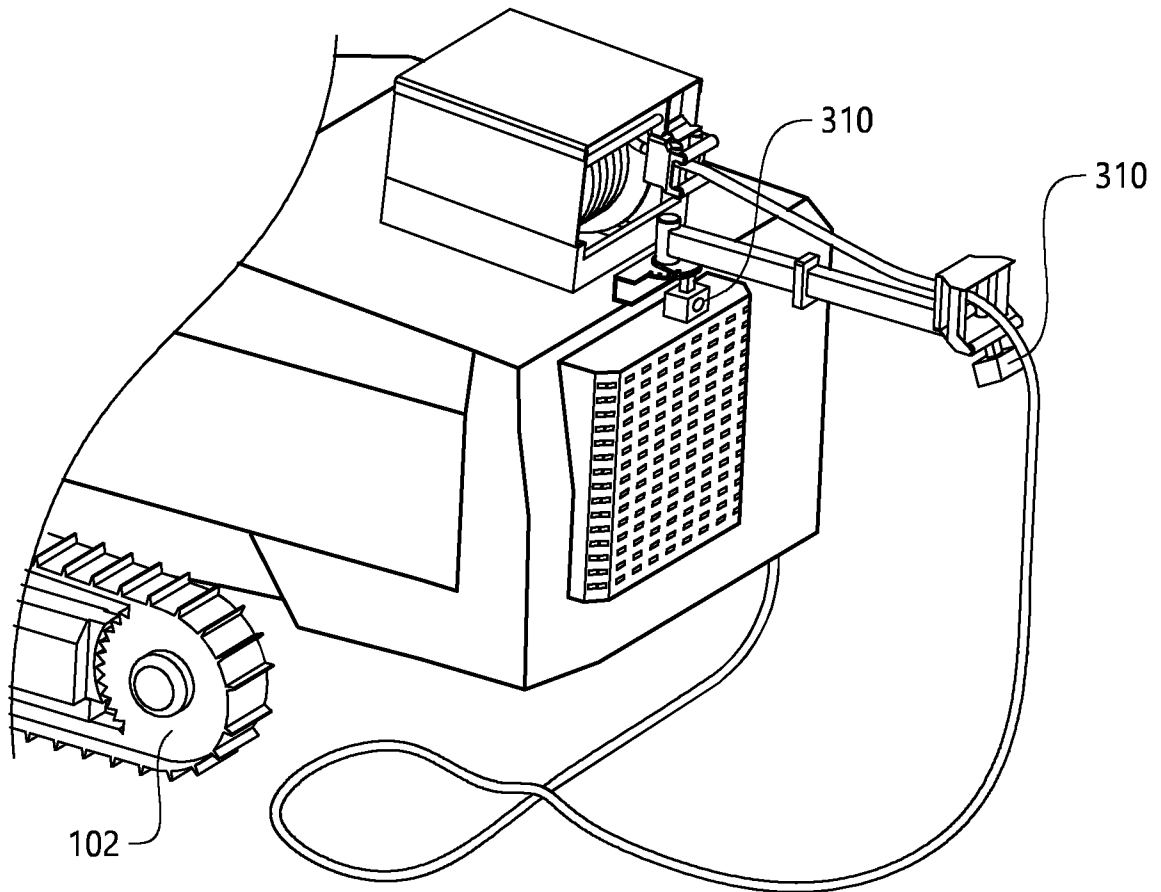


FIG. 4

5/9

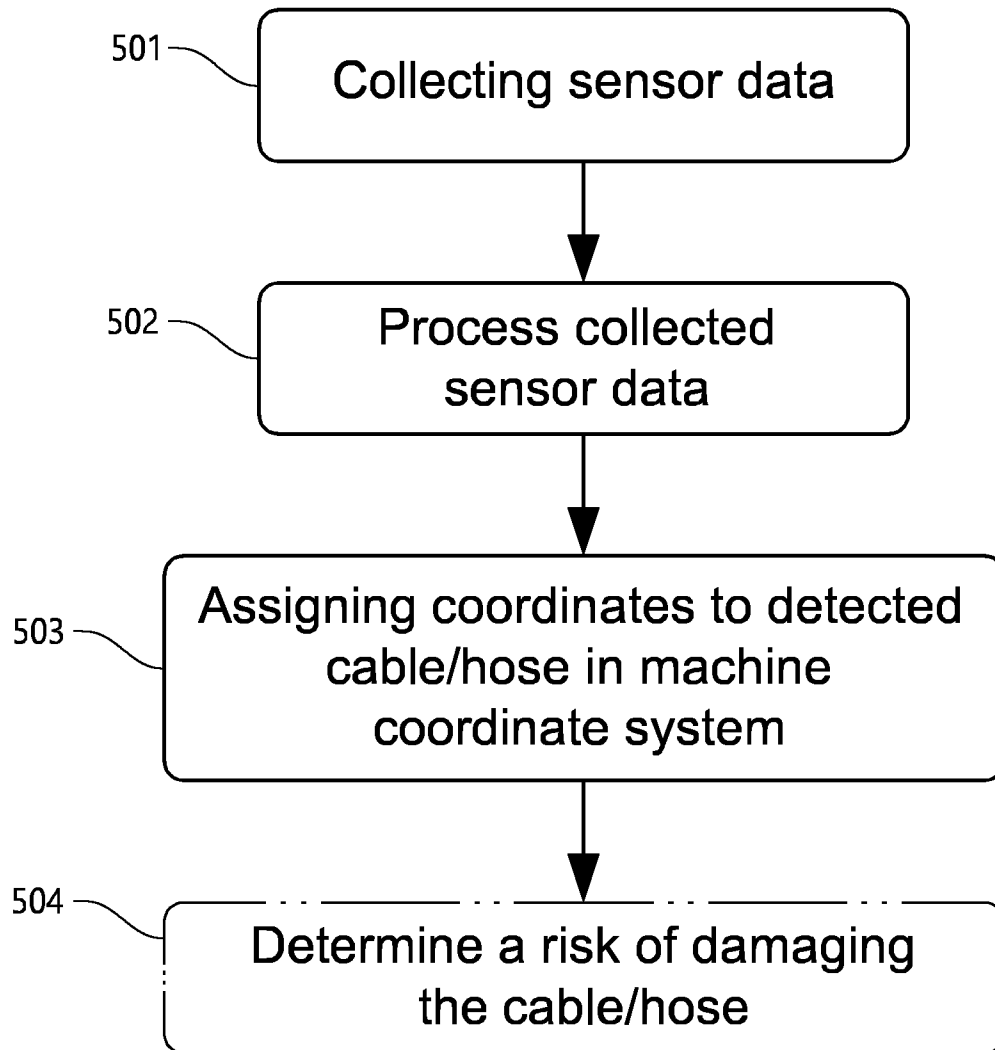


FIG. 5

6/9

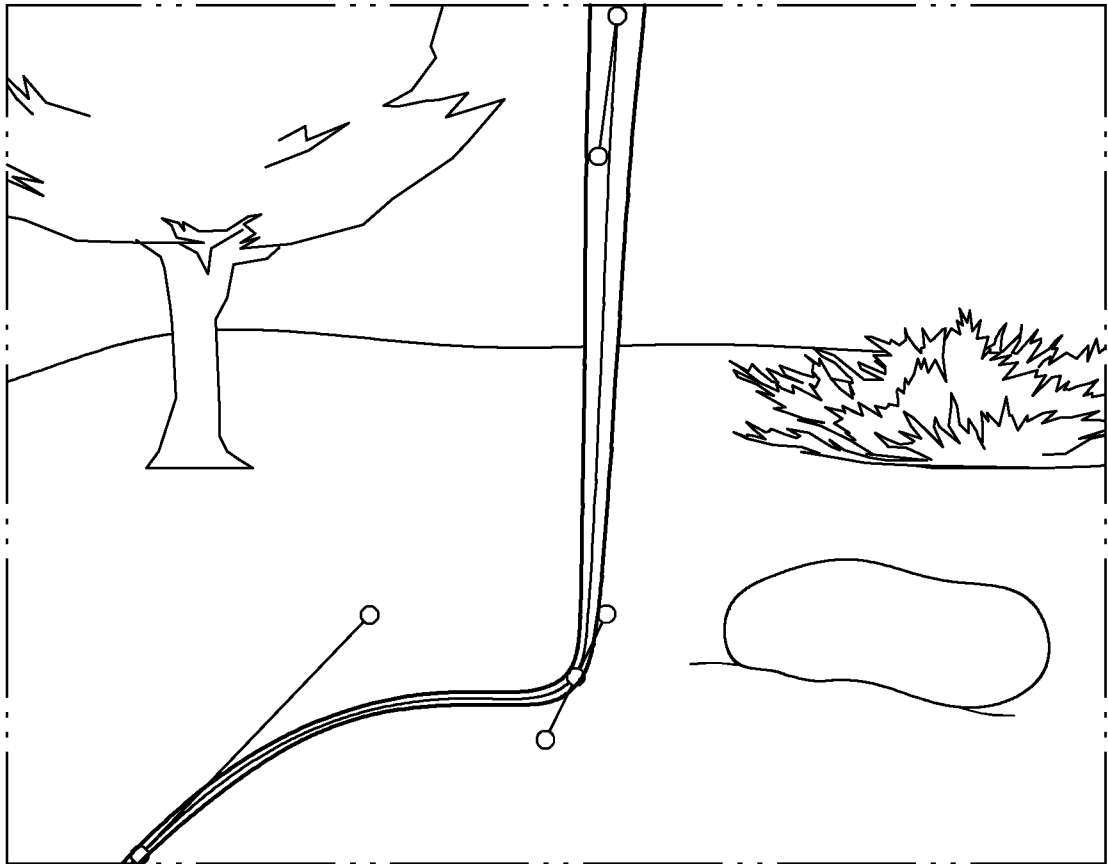


FIG. 6

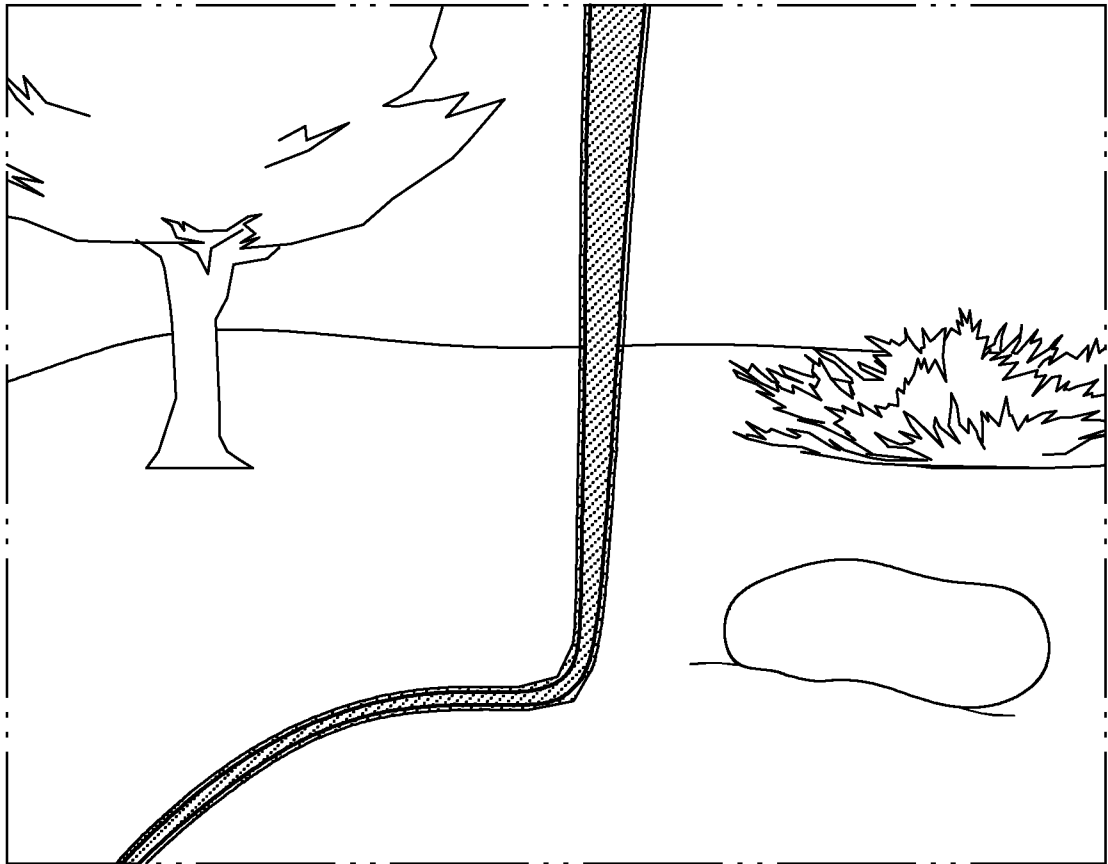


FIG. 7

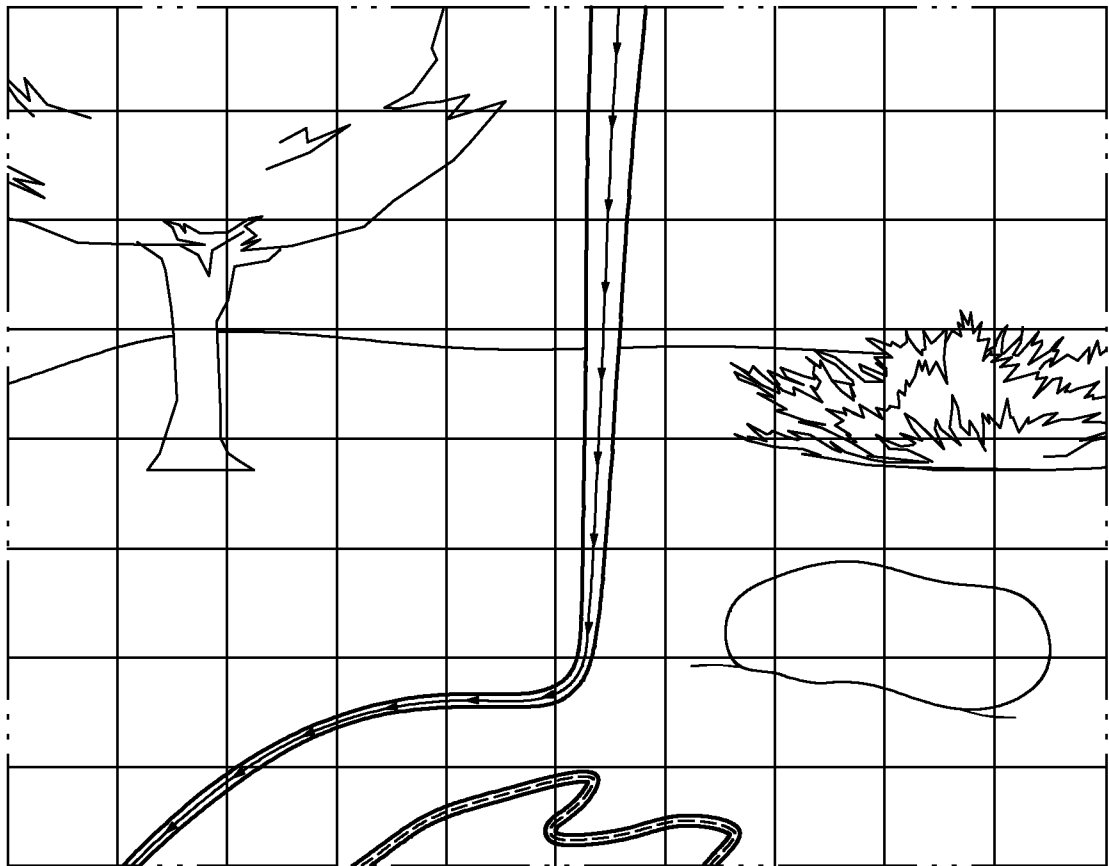


FIG. 8

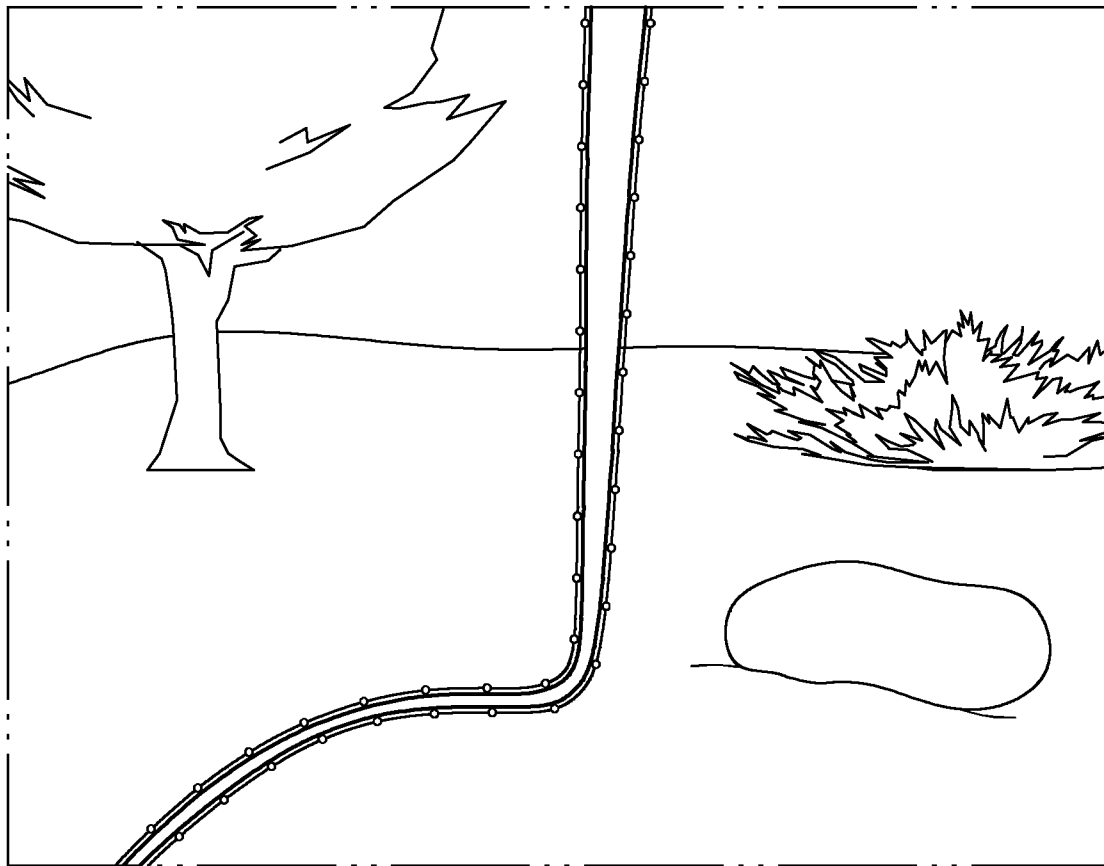


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2023/050601

A. CLASSIFICATION OF SUBJECT MATTER INV. E02F9/20 E02F9/26 E02F5/10 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) E02F		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/265962 A1 (KOCH ROGER DALE [US] ET AL) 29 October 2009 (2009-10-29)	1, 4, 6-17, 19-22
Y	the whole document	2, 5, 11, 14, 18
A	-----	3
Y	EP 3 875 697 A1 (SUMITOMO CONSTRUCTION MACHINERY CO LTD [JP]) 8 September 2021 (2021-09-08) abstract; figures 1-9	2, 5, 11, 14, 18
A	-----	1, 13, 19
A	US 2015/213605 A1 (MCCALL ROBERT C [US] ET AL) 30 July 2015 (2015-07-30) abstract; figures 1-3	1, 13, 19

<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
Date of the actual completion of the international search	Date of mailing of the international search report	
13 December 2023	04/01/2024	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Ferrien, Yann	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/SE2023/050601

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009265962 A1	29-10-2009	AU 2009201469 A1 US 2009265962 A1	12-11-2009 29-10-2009
EP 3875697 A1	08-09-2021	CN 112996963 A EP 3875697 A1 JP WO2020091002 A1 KR 20210106410 A US 2021246631 A1 WO 2020091002 A1	18-06-2021 08-09-2021 24-09-2021 30-08-2021 12-08-2021 07-05-2020
US 2015211931 A1	30-07-2015	NONE	
US 2015213605 A1	30-07-2015	NONE	