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(72) Inventors:
• **CAO, Donghui**
Jiangsu 215300 (CN)
• **SHI, Jianpeng**
Jiangsu 215300 (CN)
• **LIU, Xiaozhong**
Jiangsu 215300 (CN)

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(74) Representative: **Murgitroyd & Company**
Murgitroyd House
165-169 Scotland Street
Glasgow G5 8PL (GB)

(71) Applicant: **Sany Heavy Machinery Limited**
Kunshan, Jiangsu 215300 (CN)

(54) **ADAPTIVE CONTROL METHOD, ADAPTIVE CONTROL APPARATUS, ELECTRONIC DEVICE AND EXCAVATOR**

(57) The present disclosure provides an adaptive control method applicable to an excavator. The adaptive control method includes: acquiring detection parameters of the excavator, the detection parameters comprising a displacement of an electric control handle of the excavator and angle information of the excavator; identifying a current working condition of the excavator based on the detection parameters; and adjusting control parameters of the excavator based on the current working condition. According to the adaptive control method provided by the present disclosure, the current working condition is identified by using the displacement of the electric control handle and the angle information of the excavator, and then the control parameters of the excavator are adjusted based on the current working condition, so that the control parameters are automatically adjusted with change of the current working condition, which improves control efficiency of the excavator.

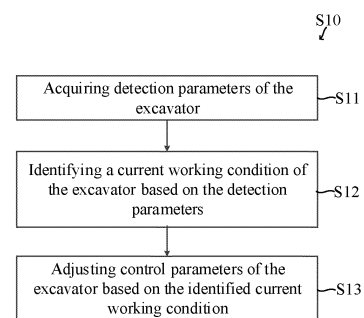


FIG. 1

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a technical field of an excavator, in particular to an adaptive control method and apparatus, an electronic device, and an excavator.

BACKGROUND

[0002] As an important building construction and mining device, excavators play a very important role in many fields such as engineering construction and ore mining. More than 60% of earthwork operations in the world are performed by the excavators.

[0003] Excavators are usually hydraulically driven to operate, and use a single or multiple pumps to drive multiple actuators such as a boom, a stick, a bucket and a swing platform, which belong to a single power source multi-actuator system. When an excavator performs compound actions, an operating speed of each actuator is determined by flow distribution of a hydraulic system, and proportion of the flow distribution is directly related to working conditions and loads. In the related art, as for some common working conditions, the excavator may preset matching working condition modes when leaving the factory, and different working condition modes correspond to different priority parameters of the flow distribution. During operation, the driver may adjust the priority parameters of the flow distribution by switching the working condition modes, so that the adjusted priority parameters match the current working condition. However, in order to realize the adjustment of the priority parameters corresponding to the current working condition, it requires the driver to select the working condition modes according to actual experience. This requires the driver to manually select and switch the working condition modes, which is less efficient and less responsive. In addition, in an actual operation, the working conditions of the excavator changes frequently. Every time the working condition changes, the driver needs to switch the working condition modes (for example, select and switch the working condition modes by operating a button). Frequent switching of the working condition modes brings a burden to the driver and reduces operating efficiency and user experience of the operator.

SUMMARY

[0004] In view of this, the present disclosure provides an adaptive control method and apparatus, an electronic device, an excavator, a computer-readable storage medium, and a computer program product.

[0005] In a first aspect, the present disclosure provides an adaptive control method applicable to an excavator, including: acquiring detection parameters of the excavator, the detection parameters comprising a displacement

of an electric control handle of the excavator and angle information of the excavator; identifying a current working condition of the excavator based on the detection parameters; and adjusting control parameters of the excavator based on the current working condition.

[0006] In the adaptive control method provided by the present disclosure, the control parameters of the excavator are adjusted based on the identified current working condition, so that the control parameters are automatically adjusted with change of the current working condition, which improves control efficiency of the excavator. In addition, combining the displacement of the electric control handle and the angle information of the excavator to identify the current working condition may ensure the reliability of identification of the working condition.

[0007] In some embodiments, the excavator includes a plurality of actuators, the plurality of actuators include a plurality of action mechanisms and a swing platform, and the angle information includes inclination angles of the plurality of action mechanisms and a swing angle of the swing platform, the identifying a current working condition of the excavator based on the detection parameters includes: acquiring relative positions of the plurality of action mechanisms; determining a lift height of the excavator based on the inclination angles and the relative positions; determining target speeds of the plurality of actuators based on the displacement and a correspondence between speeds of the plurality of actuators and the displacement of the electric control handle; and determining the current working condition based on the angle information, the lift height, and the target speeds.

[0008] The adaptive control method provided by the present disclosure combines the inclination angles, the swing angle and the target speeds to determine the current working condition, so as to realize the accuracy of the identification of the working condition.

[0009] In some embodiments, the determining a lift height of the excavator based on the inclination angles and the relative positions includes: determining a spatial coordinate of a tooth tip of the excavator at each time based on the inclination angles and the relative positions; determining a motion trajectory of the tooth tip based on the spatial coordinate of the tooth tip at each time; and determining a height difference between a crawler of the excavator and a working surface of the excavator based on the motion trajectory of the tooth tip, so as to determine the lift height.

[0010] In the adaptive control method provided by the present disclosure, the lift height is determined based on the motion trajectory of the tooth tip and the relative positions of the plurality of action mechanisms, and then the lift height is determined from the perspective of kinematic coordinate transformation, thus ensuring the accuracy of the determination of the lift height.

[0011] In some embodiments, the determining the current working condition based on the angle information, the lift height, and the target speeds includes: determining that the excavator is currently in a first mode based

on the lift height, the first mode being one of a platform building operation and a ground operation; determining that the excavator is currently in a second mode based on the inclination angles and the target speeds, the second mode being one of a loading operation and a dumping operation; determining that the excavator is currently in a third mode based on the swing angle, the third mode being one of a plurality of swing operations with different swing angles; and determining the current working condition based on the first mode, the second mode and the third mode.

[0012] In the adaptive control method provided by the present disclosure, by synthesizing the first mode, the second mode and the third mode, the current working condition is finally determined, and then an identification result of the working condition is obtained by using a signal, thus ensuring the reliability of the identification of the working condition.

[0013] In some embodiments, the determining that the excavator is currently in a first mode based on the lift height includes: determining whether the lift height exceeds a height threshold; determining that the excavator is in the platform building operation when the lift height does not exceed the height threshold; and determining that the excavator is in the ground operation when the lift height exceeds the height threshold.

[0014] In this way, it is possible to accurately determine in which of the platform building operation and the ground operation is in.

[0015] In some embodiments, the determining that the excavator is currently in a second mode based on the inclination angles and the target speeds includes: determining speed of the electric control handle based on the displacement of the electric control handle; determining target accelerations of the plurality of actuators based on the speed of the electric control handle; and determining that the excavator is currently in the second mode based on the inclination angles, the target speeds, and the target accelerations.

[0016] In the adaptive control method provided by the present disclosure, on the basis of the target speeds, the second mode is confirmed in combination with the target accelerations, which further ensures the accuracy of a determination result.

[0017] In some embodiments, the plurality of action mechanisms include a boom, a stick and a bucket.

[0018] In some embodiments, the control parameters include a pump current and a priority gain, the adjusting control parameters of the excavator based on the current working condition includes: determining target control parameters based on the current working condition and an optimization target, the optimization target including minimum fuel consumption and maximum efficiency; and adjusting the control parameters based on the target control parameters.

[0019] In the adaptive control method provided by the present disclosure, the control parameters are optimized by using the optimization target, so that the optimized

control parameters can meet the requirements.

[0020] In a second aspect, the present disclosure also provides an adaptive control apparatus applicable to an excavator, including: an acquisition module, configured to acquire detection parameters of the excavator, the detection parameters comprising a displacement of an electric control handle of the excavator and angle information of the excavator; an identification module, configured to identify a current working condition of the excavator based on the detection parameters; and an adjustment module, configured to adjust control parameters of the excavator based on the current working condition.

[0021] In a third aspect, the present disclosure also provides an electronic device, including: a processor; and a memory having program instructions stored thereon and coupled to the processor. When the program instructions are executed by the processor, the processor executes the adaptive control method described in the first aspect.

[0022] In a fourth aspect, the present disclosure also provides an excavator, including the electronic device described in the third aspect.

[0023] In a fifth aspect, the present disclosure also provides a computer-readable storage medium having program instructions stored thereon. When the program instructions are executed by a processor, the processor executes the adaptive control method described in the first aspect.

[0024] In a sixth aspect, the present disclosure also provides a computer program product, including computer programs. When the computer programs are executed by a processor, the processor executes the adaptive control method described in the first aspect.

BRIEF DESCRIPTION OF DRAWINGS

[0025] In order to explain the embodiments of the present disclosure more clearly, the accompanying drawings that need to be used may be briefly introduced below. Obviously, the accompanying drawings in the following description are some embodiments of the present disclosure. For those skilled in the art, other drawings may also be obtained from these accompanying drawings without creative efforts.

FIG. 1 is a schematic flowchart of an adaptive control method according to an embodiment of the present disclosure.

FIG. 2 is a flowchart of an adaptive control method according to another embodiment of the present disclosure.

FIG. 3 is a flowchart of an adaptive control method according to another embodiment of the present disclosure.

FIG. 4 is a schematic processing diagram of an adaptive control method according to an embodiment of the present disclosure.

FIG. 5 is a schematic structural diagram of an adap-

tive control apparatus according to an embodiment of the present disclosure.

FIG. 6 is a schematic structural diagram of an electronic device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0026] In order to make the purposes, technical solutions and advantages of the present disclosure clearer, the technical solutions in the embodiments of the present disclosure may be clearly and completely described below in combination with the accompanying drawings in the embodiments of the present disclosure. Apparently, the described embodiments are only a part, but not all, of the embodiments of the present disclosure. All of the other embodiments that are obtained by those of ordinary skill in the art based on the embodiments in the present disclosure without any inventive efforts fall into the scope protected by the present disclosure.

[0027] In the related art, a plurality of working condition buttons corresponding to a plurality of working conditions are arranged in a cab of an excavator. The driver may select a corresponding working condition button according to a current working condition, so that control parameters of actuators of the excavator may better match the current working condition of the excavator. When the working condition of the excavator changes, in order to ensure that the control parameters keep matching the changed working condition, the driver needs to select a corresponding working condition button one more time. However, due to a limited space in the cab, it is impossible to set enough working condition buttons to correspond to all possible working conditions, which results in that when a working condition that does not correspond to all the working condition buttons occurs, the driver cannot adjust optimization parameters to match the working condition. It can be seen that in the related art, control accuracy of the excavator is poor.

[0028] The present disclosure provides an adaptive control method applicable to an excavator. In the adaptive control method, the current working condition of the excavator is adaptively identified, and the control parameters of the excavator are automatically adjusted based on a result of adaptive identification, so as to realize adaptive adjustment of the control parameters.

[0029] In the adaptive control method provided by the present disclosure, the current working condition can be automatically identified based on a displacement of the electric control handle and measurement results of angle sensors. For example, various working conditions are composed of a plurality of operations such as a platform building operation/a ground operation, a loading operation/a dumping operation, a swing operation with 45-degree/90-degree/180-degree/other angle, etc. In addition, in the adaptive control method provided by the present disclosure, the control parameters of the excavator can be automatically adjusted after the current working con-

dition is identified, without manual setting and selection by the driver. For example, the adaptive control method provided by the present disclosure may be applied to the excavator using the electric control handle and the angle sensors.

[0030] It should be noted that, in the present disclosure, the steps shown in the flowcharts may be executed in a computer system such as a set of computer-executable instructions stored therein. Furthermore, although a logical order is shown in the flowcharts, in some cases the steps shown or described may be performed in an order different from that herein.

[0031] FIG. 1 is a schematic flowchart of an adaptive control method S10 according to an embodiment of the present disclosure. The adaptive control method S10 may be performed by an electronic device (e.g., a control device of an excavator). As shown in FIG. 1, the adaptive control method S10 may include steps S11 to S13.

[0032] Step S11: acquiring detection parameters of the excavator. The detection parameters include a displacement of an electric control handle of the excavator and angle information of the excavator.

[0033] During a detection period, the displacement of the electric control handle may be determined by an electric signal output by the electric control handle. Based on the displacement of the electronic control handle, target speed or target acceleration of the excavator may be determined in the subsequent steps, so that working data of the excavator may be determined. For example, a loading operation process may mainly include the following working cycles: digging-lifting-turning-unloading-returning. In each working cycle, the target speed or target acceleration of each actuator of the excavator may change accordingly. Or in each working cycle, the target speed or target acceleration of each actuator of the excavator may follow a certain variation law. Therefore, the displacement of the electronic control handle may be used to determine the working data of the excavator.

[0034] The angle information may include a measured swing angle of the swing platform of the excavator, and may also include measured inclination angles of a plurality of action mechanisms of the excavator. For example, in one detection cycle, by measuring the inclination angles of a boom, a variation law of the boom in one detection cycle may be determined. For another example, in one detection cycle, a lift height of the excavator may be determined by measuring a motion trajectory of a tooth tip of the excavator.

[0035] In the embodiment of the present disclosure, the angle information may be obtained by using the angle sensors, or the angle information may be obtained by means of image analysis. The embodiment of the present disclosure does not specifically limit the way of obtaining the angle information, and the way of obtaining the angle information may be set correspondingly according to the actual situations. Taking the implementation with angle sensors as an example, measurement results (i.e., the angle information) obtained by the angle sensors may

be sent to the electronic device, and thus, the electronic device has got the detection parameters of the excavator.

[0036] Step S12: identifying a current working condition of the excavator based on the detection parameters.

[0037] After the electronic device has got the detection parameters, the displacement of the electric control handle may be first analyzed to determine the working data of the excavator, and then the current working condition of the excavator may be further confirmed combined with the measurement results of various angle sensors.

[0038] In one example, the working conditions able to be identified by the electronic device include at least 16 types which are composed of various operations such as the ground operation/platform building operation, the loading operation/dumping operation, the swing operation with 45-degree/90-degree/180-degree/other angle, etc. (for example, a platform building and dumping working condition with 90-degree is one of the working conditions).

[0039] Step S13: adjusting control parameters of the excavator based on the identified current working condition.

[0040] The control parameters corresponding to various working conditions may be stored in the electronic device. For example, these control parameters may be stored in a form of a data table. After the current working condition is determined, through the electronic device, the working condition may be matched in the data table, and the corresponding control parameters may be extracted when the same working condition as the current working condition is matched.

[0041] For example, the control parameters may include a pump current and a priority gain. The pump current may be a pump current corresponding to each action mechanism in the excavator. The priority gain may be a priority gain of the swing platform to the boom, a priority gain of the swing platform to a stick, a priority gain of the stick to a bucket, and so on. The specific pump current and specific priority gain included in the control parameters are not limited here, and may be set according to the actual situations.

[0042] In the adaptive control method provided in this embodiment, the current working condition is identified by using the displacement of the electric control handle of the excavator and the angle information of the excavator, and then the control parameters of the excavator are adjusted based on the current working condition, so as to realize that the control parameters are automatically adjusted with the change of the current working condition, and the control efficiency of the excavator is improved.

[0043] FIG. 2 is a schematic flowchart of an adaptive control method S20 according to another embodiment of the present disclosure. The adaptive control method S20 may be performed by an electronic device (e.g., a control device of an excavator). As shown in FIG. 2, the adaptive control method S20 may include steps S21 to S23.

[0044] Step S21: acquiring detection parameters of the excavator. The detection parameters include a displacement

of an electric control handle of the excavator and angle information of the excavator.

[0045] The angle information includes inclination angles and a swing angle. The inclination angles may be inclination angles of a plurality of action mechanisms of the excavator. For example, the plurality of action mechanisms include a boom, a stick and a bucket, etc. The swing angle may be a swing angle of the swing platform of the excavator. In the present disclosure, the angle information may be set according to the actual needs, which is not limited herein. By using a swing angle sensor, change amplitude of the swing angle and a swing direction in a loading cycle are acquired through the electronic device, and therefore, the swing angle of the excavator during operation may be identified.

[0046] Step S22: identifying a current working condition of the excavator based on the detection parameters.

[0047] As an embodiment, the step S22 may include steps S221 to S224.

[0048] Step S221: acquiring relative positions of the plurality of action mechanisms of the excavator.

[0049] Through the electronic device, a coordinate system (e.g., a XOY coordinate system) may be established with a tooth tip of the excavator (e.g., a bucket) as a coordinate center point. Since a size of each action mechanism in the excavator is fixed, a coordinate of each action mechanism in the coordinate system may be determined, so that the relative position of each action mechanism may be determined.

[0050] For example, the relative position of each action mechanism may be pre-stored in the electronic device. For another example, through the electronic device, a coordinate system may be established in real time and the relative position of each action mechanism may also be determined in real time when self-adaptive control is required. Of course, through the electronic device, the relative position of each action mechanism in the excavator may also be acquired in other ways. The present disclosure does not specifically limit the manner of how to acquire the relative position of each action mechanism in the excavator through electronic device.

[0051] Step S222: determining a lift height of the excavator based on the inclination angles and the relative positions.

[0052] As described above, the inclination angles may include the inclination angles of the boom, the stick, and the bucket. Therefore, through the electronic device, the lift height of the excavator may be determined according to the inclination angles of the corresponding action mechanisms and their relative positions.

[0053] As a specific embodiment, the step S222 may include: determining a spatial coordinate of a tooth tip of the excavator at each time based on the inclination angles and the relative positions; determining a motion trajectory of the tooth tip based on the spatial coordinate of the tooth tip at each time; and determining a height difference between a crawler of the excavator and a working surface of the excavator based on the motion trajectory

of the tooth tip, so as to determine the lift height.

[0054] By using inclination sensors, through the electronic device, an angle of each action mechanism (i.e. the boom, stick and bucket) at each time may be obtained, and combined with the relative position of each action mechanism (or a geometric dimension of the boom, stick and bucket and a dimension of a hydraulic cylinder), the spatial coordinate of the tooth tip of the excavator may be obtained according to a space coordinate operation. Through the electronic device, the motion trajectory of the tooth tip may be determined by recording the spatial coordinate of the tooth tip at each time. Through the electronic device, a height of a crawler of the excavator relative to a working surface of the excavator may be identified by using the motion trajectory of the tooth tip during an excavation process, so as to determine the lift height.

[0055] As an example, the working surface of the excavator may refer to a plane on which the tooth tip of the bucket are located when the bucket of the excavator is lifted to the highest level in the current operation, or the working surface of the excavator may be a plane on which the highest point of the motion trajectory of the tooth tip is located. As an example, the lift height may be a height difference between the crawler of the excavator (or a plane supporting the crawler) and the working surface of the excavator.

[0056] The lift height is determined based on the motion trajectory of the tooth tip and the relative position of each action mechanism, and the lift height is determined from a perspective of kinematic coordinate conversion, which ensures the accuracy of determining the lift height.

[0057] Step S223: determining target speeds of the plurality of actuators based on the displacement of the electric control handle and a correspondence between speeds of the plurality of actuators and a displacement of the electric control handle.

[0058] In one example, the correspondence between speeds of the plurality of actuators and the displacement of the electric control handle may be stored in the electronic device, and the correspondence may be characterized by a relationship curve. After the displacement of the electric control handle is obtained, through the electronic device, the target speeds of the plurality of actuators may be determined by looking up the relationship curve.

[0059] Step S224: determining the current working condition based on the angle information, the lift height, and the target speeds.

[0060] As described above, the target speeds can characterize the working data of the excavator. Therefore, through the electronic device, the current working condition may be determined by combining the angle, lift height and target speeds.

[0061] In a specific embodiment, the step S224 may include steps S2241 to S2244.

[0062] Step S2241: determining that the excavator is currently in a first mode based on the lift height. The first

mode is one of a platform building operation and a ground operation.

[0063] By comparing the lift height with a height threshold, a current mode of the excavator may be determined, that is, which of the platform building operation and the ground operation the excavator is currently in.

[0064] As an example, the step S2241 may include determining whether the lift height exceeds a height threshold; determining that the excavator is in the platform building operation when the lift height does not exceed the height threshold; and determining that the excavator is in the ground operation when the lift height exceeds the height threshold.

[0065] Step S2242: determining that the excavator is currently in a second mode based on the inclination angles and the target speeds. The second mode is one of a loading operation and a dumping operation.

[0066] In a detection cycle, the working data of the excavator may be characterized by the target speeds, and working characteristics of the excavator may be expressed by the target speeds. Based on the working characteristics and the inclination angles, through the electronic device, it may be determined which of the loading operation and the dumping operation is currently performed by the excavator.

[0067] Step S2243: determining that the excavator is currently in a third mode based on the swing angle. The third mode is one of a plurality of swing operations with different swing angles.

[0068] For example, various swing operations may include a swing operation with a swing angle of 45 degrees, a swing operation with a swing angle of 90 degrees, a swing operation with a swing angle of 180 degrees, a swing operation with other swing angles, and the like. Based on the detected swing angle, through the electronic device, it may be determined which of various swing operations the excavator is currently in. For example, if the detected swing angle is close to 90 degrees, it may be determined that the excavator is currently in the swing operation with the swing angle of 90 degrees, i.e., a current swing platform of the excavator needs to be rotated 90 degrees for operation.

[0069] Step S2244: determining the current working condition based on the first mode, the second mode and the third mode.

[0070] By combining the first mode, the second mode and the third mode, the current working condition of the excavator may be finally determined through the electronic device. For example, if the determined first mode is the ground operation, the determined second mode is the loading operation, and the determined third mode is the swing operation with the swing angle of 90 degrees, then by combining these information, it may be determined that the current working condition of the excavator is 90-degree leveling loading. For another example, if the determined first mode is the platform building operation, the determined second mode is the dumping operation, and the determined third mode is the swing operation

with the swing angle of 45 degrees, then by combining these information, it may be determined that the current working condition of the excavator is 45-degree platform building dumping.

[0071] By synthesizing the first mode, the second mode and the third mode, the current working condition is finally determined, which may ensure the reliability of determining the current working condition.

[0072] In a specific embodiment, the step S2242 may include: determining speed of the electric control handle based on the displacement of the electric control handle; determining target accelerations of the plurality of actuators based on the speed of the electric control handle; and determining that the excavator is currently in the second mode based on the inclination angles, the target speeds, and the target accelerations.

[0073] There is a correspondence between the displacement and the speed of the electric control handle. After the displacement of the electric control handle is obtained, through the electronic device, the speed of the electric control handle may be obtained by using the correspondence. For example, the speed of the electric control handle may be obtained through the displacement of the electric control handle and a corresponding time. Through the electronic device, a differential calculation is performed on the obtained speed of the electric control handle to determine the target accelerations of the excavator. For example, when the driver operates the electric control handle, the speed of moving the electric control handle (i.e., the speed of the electric control handle) is related to acceleration of the excavator expected by the driver. The faster the driver moves the electric control handle, the faster the driver expects the excavator to respond to changes in speed. On the basis of the target speeds, the working characteristics of the excavator are determined in combination with the target accelerations, which further ensures the accuracy of a determination result.

[0074] Step S23: adjusting the control parameters of the excavator based on the identified current working condition. The control parameters include a pump current and a priority gain.

[0075] It should be noted that, for a specific embodiment of the step S23, reference may be made to the step S13 in the foregoing embodiment, which is not repeated here for the sake of brevity.

[0076] In the adaptive control method provided in this embodiment, the inclination angles, the swing angle and the target speeds are combined to determine the current working condition, so as to realize the accuracy of identifying the working condition.

[0077] FIG. 3 is a flowchart of an adaptive control method of a step S30 according to another embodiment of the present disclosure. The adaptive control method of the step S30 may be performed by an electronic device (e.g., a control device of an excavator). As shown in FIG. 3, the adaptive control method of the step S30 may include steps S31 to S33.

[0078] Step S31: acquiring detection parameters of the excavator. The detection parameters include a displacement of an electric control handle of the excavator and angle information of the excavator.

[0079] For a specific embodiment of the step S31, reference may be made to the step S21 in the above embodiment, and for the sake of brevity, details are not described herein again.

[0080] Step S32: identifying a current working condition of the excavator based on the detection parameters.

[0081] As for the identification of the current working condition of the excavator, as shown in FIG. 4, input parameters are the displacement of the electric control handle, inclination angles of a plurality of action mechanisms, and a swing angle of a swing platform, and an output is a pump current and a priority gain. For example, inclination sensors may be provided in the excavator to acquire the inclination angles of the plurality of action mechanisms, and a swing angle sensor may be provided in the excavator to detect the swing angle of the swing platform. Considering that a position of the electric control handle corresponds to an operating speed of a plurality of actuators of the excavator during operation, the driver's expected speed may be identified according to the position of the electric control handle, and the driver's expected acceleration may be identified according to a speed of the electric control handle. In addition, the lift height of the excavator may be determined according to the inclination angles of the plurality of action mechanisms. In addition, an angle that the swing platform has turned during the operation may be determined according to the swing angle. Comprehensively, the current working condition of the excavator may be identified. According to the identified current working condition, aiming at the lowest fuel consumption and the highest efficiency, the pump current and priority gain are automatically adjusted to automatically adapt to the current working condition, so that each action gain coefficient is more suitable for the current working condition. In this embodiment, there is no need for the driver to repeatedly adjust manually, which can reduce the difficulty of the operation and increase the working efficiency.

[0082] As an example, a display screen or button etc. may be provided on the excavator for the driver to activate/deactivate an adaptive mode. After the driver chooses to enter the adaptive mode, through the electronic device (such as the control device of the excavator), corresponding parameters may be automatically adjusted according to different working conditions, so as to automatically adapt to different working conditions.

[0083] Step S33: adjusting control parameters of the excavator based on the current working condition. The control parameters may include a pump current and a priority gain. In a non-limiting example, the step S33 may include step S331 and step S332.

[0084] Step S331: determining target control parameters based on the current working condition and an optimization target. The optimization target includes mini-

mum fuel consumption and maximum efficiency.

[0085] After the current working condition is identified, through the electronic device, the control parameter corresponding to the current working condition may be determined in combination with the current working condition and the optimization target, i.e., the target control parameter. Specifically, as shown in FIG. 4, the optimization target may include the minimum fuel consumption, maximum efficiency, best operation, and highest cost performance. After constraints corresponding to each optimization target are determined, an optimization function may be used to optimize the control parameters, and then the target control parameters corresponding to the current working condition may be determined.

[0086] It should be understood that although only two pump currents and three priority gains are shown in FIG. 4, the protection scope of the present invention is not limited to this, and specific settings may be made according to the actual needs.

[0087] Step S332: adjusting the (current) control parameters of the excavator based on the target control parameters.

[0088] After the target control parameters are determined, through the electronic device, a value of the current control parameter may be adjusted (for example, the current control parameter is adjusted to be consistent with the target control parameter), thereby realizing adaptive control of the excavator.

[0089] In the adaptive control method provided in this embodiment, the optimization target is used to optimize the control parameters, so that the optimized control parameters can meet the requirements.

[0090] As shown in FIG. 4, in the adaptive control method of the present disclosure, the working condition of the excavator is automatically identified according to signals such as the displacement of the electric control handle, the speed of the electric control handle, the inclination angles of the action mechanism, and the swing angle of the swing platform. Using the above signals to identify the working condition can make the identification of the working condition more specific. In the related art, the inclination angles of the action mechanism and the swing angle of the swing platform are not included, so only some simple working conditions (such as light or heavy load, excavation or crushing) can be roughly identified, and it is difficult to accurately determine the working condition.

[0091] Further, according to the identified working condition, the pump current and priority gain are automatically adjusted to automatically adapt to different working conditions, so that the gain coefficient of each action is more suitable for the current working condition, without the driver's repeated manual adjustment, reducing the operation difficulty and increasing the working efficiency.

[0092] Specifically, the input signals of the adaptive control method in the present disclosure are: the displacement of the electric control handle, the speed of the electric control handle, and the inclination angles and swing angle detected by the angle sensors. For example,

the working conditions that can be identified may include at least 16 working conditions which are composed of various operations such as the ground operation/platform building operation, the loading operation/dumping operation, the swing operation with 45-degree/90-degree/180-degree/other angle, etc. (for example, a platform building and dumping working condition with 90-degree is one of the working conditions). The output pump current and the priority gain of each action are automatically adjusted according to the identified working condition, and the driver is not required to manually set and select the working condition.

[0093] As an alternative embodiment, a display screen or button etc. may be provided on the excavator for the driver to activate/deactivate an adaptive mode. After the driver chooses to enter the adaptive mode, through the electronic device (such as the control device of the excavator), corresponding parameters may be automatically adjusted according to different working conditions, so as to automatically adapt to different working conditions. It should be understood that the implementation of activating/deactivating the adaptive mode is not limited to the button, display screen, etc. In other embodiments, other implementations may also be adopted.

[0094] The present embodiment also provides an adaptive control apparatus, applicable to an excavator. The adaptive control apparatus provided in the present disclosure corresponds to the adaptive control method provided in the present disclosure one-to-one. Repeated description is omitted as appropriate for the sake of brevity. As used below, the term "module" may be a combination of software and/or hardware that implements a predetermined function. Although the apparatus described in the following embodiments is preferably implemented in software, hardware, or a combination of software and hardware, is also possible and contemplated.

[0095] FIG. 5 is a schematic structural diagram of an adaptive control apparatus 40 according to an embodiment of the present disclosure. As shown in FIG. 5, the adaptive control apparatus 40 may include an acquisition module 41, an identification module 42, and an adjustment module 43.

[0096] The acquisition module 41 is configured to acquire detection parameters of the excavator. The detection parameters include a displacement of an electric control handle of the excavator and angle information of the excavator.

[0097] The identification module 42 is configured to identify a current working condition of the excavator based on the detection parameters.

[0098] The adjustment module 43 is configured to adjust control parameters of the excavator based on the current working condition.

[0099] The adaptive control apparatus, applicable to the excavator, in this embodiment is presented in the form of a functional unit, which may adopt one or a combination of the following forms: an ASIC circuit, a proc-

essor that executes one or more software or fixed programs, and other components that may provide the above functions.

[0100] In some embodiments, referring again to FIG. 5, the identification module 42 may include a first unit 421, a second unit 422, a third unit 423, and a fourth unit 424. The angle information may include inclination angles of a plurality of action mechanisms of the excavator and a swing angle of a swing platform of the excavator.

[0101] The first unit 421 is configured to acquire relative positions of the plurality of action mechanisms. The second unit 422 is configured to determine a lift height of the excavator based on the inclination angles and the relative positions. The third unit 423 is configured to determine target speeds of the plurality of actuators based on the displacement and a correspondence between speeds of the plurality of actuators and the displacement of the electric control handle. The fourth unit 424 is configured to determine the current working condition based on the angle information, the lift height, and the target speeds.

[0102] In some embodiments, the second unit 422 is configured to: determine a spatial coordinate of a tooth tip of the excavator at each time based on the inclination angles and the relative positions; determine a motion trajectory of the tooth tip based on the spatial coordinate of the tooth tip at each time; and determine a height difference between a crawler of the excavator and a working surface of the excavator based on the motion trajectory of the tooth tip, so as to determine the lift height.

[0103] In some embodiments, referring again to FIG. 5, the fourth unit 424 may include a first sub-unit 4241, a second sub-unit 4242, a third sub-unit 4243, and a fourth sub-unit 4244.

[0104] The first sub-unit 4241 is configured to determine that the excavator is currently in a first mode based on the lift height. The first mode is one of a platform building operation and a ground operation.

[0105] The second sub-unit 4242 is configured to determine that the excavator is currently in a second mode based on the inclination angles and the target speeds. The second mode is one of a loading operation and a dumping operation.

[0106] The third sub-unit 4243 is configured to determine that the excavator is currently in a third mode based on the swing angle. The third mode is one of a plurality of swing operations with different swing angles.

[0107] The fourth sub-unit 4244 is configured to determine the current working condition based on the first mode, the second mode and the third mode.

[0108] In some embodiments, the first sub-unit is configured to: determine whether the lift height exceeds a height threshold; determine that the excavator is in the platform building operation when the lift height does not exceed the height threshold; and determine that the excavator is in the ground operation when the lift height exceeds the height threshold.

[0109] In some embodiments, the second sub-unit is

configured to: determine speed of the electric control handle based on the displacement of the electric control handle; determine target accelerations of the plurality of actuators based on the speed of the electric control handle; and determine that the excavator is currently in the second mode based on the inclination angles, the target speeds, and the target accelerations.

[0110] In some embodiments, the adjustment module 43 is configured to: determine target control parameters based on the current working condition and an optimization target; and adjust the control parameters based on the target control parameters. The optimization target include minimum fuel consumption and maximum efficiency.

[0111] FIG. 6 is a schematic structural diagram of an electronic device 50 according to an embodiment of the present disclosure. As shown in FIG. 6, the electronic device 50 may include at least one processor 51, at least one communication interface 53, a memory 54, and at least one communication bus 52. The communication bus 52 is used to realize connection communication between these components. The communication interface 53 may include a display screen and a keyboard, and the communication interface 53 may optionally also include a standard wired interface and a wireless interface. The memory 54 may be a high-speed Random Access Memory (RAM) or a non-volatile memory, such as at least one disk memory. The memory 54 may alternatively be at least one storage apparatus located away from the aforementioned processor 51. The processor 51 may call program code stored in the memory 54 for performing any of the steps in any of the methods described above.

[0112] The communication bus 52 may be a Peripheral Component Interconnect (PCI) bus, an Extended Industry Standard Architecture (EISA) bus, or the like. The communication bus 52 may be divided into an address bus, a data bus, control bus, or the like.

[0113] The memory 54 may include a volatile memory, such as a Random Access Memory (RAM); The memory may also include a non-volatile memory, such as a flash memory, a Hard Disk Drive (HDD), or a Solid State Drive (SSD). The memory 54 may also include a combination of the above types of memories.

[0114] The processor 51 may be a Central Processing Unit (CPU), a Network Processor (NP), or a combination of CPU and NP.

[0115] The processor 51 may further include a hardware chip. The above hardware chip may be an Application Specific Integrated Circuit (ASIC), a Programmable Logic Device (PLD), or a combination thereof. The PLD may be a Complex Programmable Logic Device (CPLD), a Field Programmable Gate Array (FPGA), a General Array Logic (GAL), or any combination thereof.

[0116] Optionally, the memory 54 is also used to store program instructions. The processor 51 may call the program instructions to implement the adaptive control method shown in the embodiments of FIG. 1 to FIG. 3 of the present application.

[0117] The present disclosure also provides a computer-readable storage medium. The computer-readable storage medium stores program instructions. When the program instructions are executed by the processor, the processor executes the adaptive control method provided by the present disclosure.

[0118] In the present disclosure, the computer storage medium may be a magnetic disk, an optical disk, a Read Only Memory (ROM), a Random Access Memory (RAM), a flash memory, a Hard Disk Drive (HDD), a Solid State Drive (SSD), and the like. In some embodiments, the computer storage medium may also include a combination of the above types of memories.

[0119] The present disclosure also provides an excavator including the electronic device provided in the present disclosure.

[0120] By way of example, the excavator may include an excavator body and the electronic device. The electronic device is connected with the excavator body. The electronic device may be connected with the excavator body according to the needs. The specific connection manner and setting position of the excavator and the electronic device are not limited here.

[0121] The specific structure of the excavator body may be set according to the actual needs, and there is no limitation here. The electronic device is used to automatically identify the current working condition of the excavator, and adaptively adjust the control parameters of the excavator based on the current working condition, so that the excavator may automatically adapt to different working conditions, thereby reducing the working difficulty, increasing the working efficiency, and eliminating the need for the driver to manually select the working mode.

[0122] The present disclosure also provides a computer program product. The computer program product includes computer programs. When the computer programs are executed by a processor, the processor executes the adaptive control method provided by the present disclosure.

[0123] It should be noted that in the present disclosure, the excavator may include a traveling mechanism, a swing platform, and a plurality of action mechanisms. For example, the traveling mechanism may be a crawler. The swing platform is also called an upper part turntable or an upper part body, which is installed on the traveling mechanism. The swing platform may include, for example, a cab and counterweights, etc. The plurality of action mechanisms may include a boom, a stick and a bucket, etc. The plurality of action mechanisms are installed on the swing platform to follow the swing platform to rotate.

[0124] It should be noted that, in the present disclosure, the loading operation may mean that the excavator loads materials onto another transport vehicle (e.g., a truck); the dumping operation may mean that the excavator directly moves materials from one place to another without the help of other transportation vehicles. It should also be noted that, in the present disclosure, the platform building operation may mean that the excavator working

on a pre-built platform. Correspondingly, the ground operation may mean that the excavator operates on a flat ground. For example, in one loading operation, if the excavator and the truck are on a same plane (i.e. a ground height supporting the excavator and the truck are the same), this operation manner may be called the ground operation. If the plane where the excavator is located is higher than the plane where the truck is located (for example, the truck is on the ground and the excavator is on a platform higher than the ground), this operation manner may be called the platform building operation. In a loading and unloading operation, as for a same truck, if the platform building operation is adopted, the lift height of the bucket of the excavator is low; if the ground operation is adopted, the bucket of the excavator needs to be lifted to a higher height.

[0125] Although the embodiments of the present disclosure have been described in conjunction with the drawings, those skilled in the art may make various modifications and variations without departing from the spirit and scope of the present disclosure, and such modifications and variations fall within the scope defined by the appended claims.

Claims

1. An adaptive control method, applicable to an excavator, wherein the adaptive control method comprises:

acquiring detection parameters of the excavator, the detection parameters comprising a displacement of an electric control handle of the excavator and angle information of the excavator;
identifying a current working condition of the excavator based on the detection parameters; and
adjusting control parameters of the excavator based on the current working condition.

2. The adaptive control method of claim 1, wherein the excavator comprises a plurality of actuators, the plurality of actuators comprise a plurality of action mechanisms and a swing platform, and the angle information comprises inclination angles of the plurality of action mechanisms and a swing angle of the swing platform, the identifying a current working condition of the excavator based on the detection parameters comprises:

acquiring relative positions of the plurality of action mechanisms;
determining a lift height of the excavator based on the inclination angles and the relative positions;
determining target speeds of the plurality of actuators based on the displacement and a corre-

- spondence between speeds of the plurality of actuators and the displacement of the electric control handle; and
determining the current working condition based on the angle information, the lift height, and the target speeds.
3. The adaptive control method of claim 2, wherein the determining a lift height of the excavator based on the inclination angles and the relative positions comprises:
- determining a spatial coordinate of a tooth tip of the excavator at each time based on the inclination angles and the relative positions;
determining a motion trajectory of the tooth tip based on the spatial coordinate of the tooth tip at each time; and
determining a height difference between a crawler of the excavator and a working surface of the excavator based on the motion trajectory of the tooth tip, so as to determine the lift height.
4. The adaptive control method of claim 2 or 3, wherein the determining the current working condition based on the angle information, the lift height, and the target speeds comprises:
- determining that the excavator is currently in a first mode based on the lift height, the first mode being one of a platform building operation and a ground operation;
determining that the excavator is currently in a second mode based on the inclination angles and the target speeds, the second mode being one of a loading operation and a dumping operation;
determining that the excavator is currently in a third mode based on the swing angle, the third mode being one of a plurality of swing operations with different swing angles; and
determining the current working condition based on the first mode, the second mode and the third mode.
5. The adaptive control method of claim 4, wherein the determining that the excavator is currently in a first mode based on the lift height comprises:
- determining whether the lift height exceeds a height threshold;
determining that the excavator is in the platform building operation when the lift height does not exceed the height threshold; and
determining that the excavator is in the ground operation when the lift height exceeds the height threshold.
6. The adaptive control method of claim 4 or 5, wherein the determining that the excavator is currently in a second mode based on the inclination angles and the target speeds comprises:
- determining speed of the electric control handle based on the displacement of the electric control handle;
determining target accelerations of the plurality of actuators based on the speed of the electric control handle; and
determining that the excavator is currently in the second mode based on the inclination angles, the target speeds, and the target accelerations.
7. The adaptive control method of any one of claims 2 to 6, wherein the plurality of action mechanisms comprise a boom, a stick and a bucket.
8. The adaptive control method of any one of claims 1 to 7, wherein the control parameters comprise a pump current and a priority gain, the adjusting control parameters of the excavator based on the current working condition comprises:
- determining target control parameters based on the current working condition and an optimization target, the optimization target comprising minimum fuel consumption and maximum efficiency; and
adjusting the control parameters based on the target control parameters.
9. An adaptive control apparatus, applicable to an excavator, wherein the adaptive control apparatus comprises:
- an acquisition module, configured to acquire detection parameters of the excavator, the detection parameters comprising a displacement of an electric control handle of the excavator and angle information of the excavator;
an identification module, configured to identify a current working condition of the excavator based on the detection parameters; and
an adjustment module, configured to adjust control parameters of the excavator based on the current working condition.
10. The adaptive control apparatus of claim 9, wherein the excavator comprises a plurality of actuators, the plurality of actuators comprise a plurality of action mechanisms and a swing platform, and the angle information comprises inclination angles of the plurality of action mechanisms and a swing angle of the swing platform, the identification module comprises:
- a first unit, configured to acquire relative posi-

- tions of the plurality of action mechanisms;
 a second unit, configured to determine a lift height of the excavator based on the inclination angles and the relative positions;
 a third unit, configured to determine target speeds of the plurality of actuators based on the displacement and a correspondence between speeds of the plurality of actuators and the displacement of the electric control handle; and
 a fourth unit, configured to determine the current working condition based on the angle information, the lift height, and the target speeds.
11. The adaptive control apparatus of claim 10, wherein the second unit is configured to: determine a spatial coordinate of a tooth tip of the excavator at each time based on the inclination angles and the relative positions; determine a motion trajectory of the tooth tip based on the spatial coordinate of the tooth tip at each time; and determine a height difference between a crawler of the excavator and a working surface of the excavator based on the motion trajectory of the tooth tip, so as to determine the lift height.
12. The adaptive control apparatus of claim 10 or 11, wherein the fourth unit comprises:
- a first sub-unit, configured to determine that the excavator is currently in a first mode based on the lift height, the first mode being one of a platform building operation and a ground operation;
 a second sub-unit, configured to determine that the excavator is currently in a second mode based on the inclination angles and the target speeds, the second mode being one of a loading operation and a dumping operation;
 a third sub-unit, configured to determine that the excavator is currently in a third mode based on the swing angle, the third mode being one of a plurality of swing operations with different swing angles; and
 a fourth sub-unit, configured to determine the current working condition based on the first mode, the second mode and the third mode.
13. The adaptive control apparatus of claim 12, wherein the first sub-unit is configured to: determine whether the lift height exceeds a height threshold; determine that the excavator is in the platform building operation when the lift height does not exceed the height threshold; and determine that the excavator is in the ground operation when the lift height exceeds the height threshold.
14. The adaptive control apparatus of claim 12 or 13, wherein the second sub-unit is configured to: determine speed of the electric control handle based on the displacement of the electric control handle; determine target accelerations of the plurality of actuators based on the speed of the electric control handle; and determine that the excavator is currently in the second mode based on the inclination angles, the target speeds, and the target accelerations.
15. The adaptive control apparatus of any one of claims 10 to 14, wherein the plurality of action mechanisms comprise a boom, a stick and a bucket.
16. The adaptive control apparatus of any one of claims 9 to 15, wherein the control parameters comprise a pump current and a priority gain, the adjustment module is configured to: determine target control parameters based on the current working condition and an optimization target, the optimization target comprising minimum fuel consumption and maximum efficiency; and adjust the control parameters based on the target control parameters.
17. An electronic device, comprising:
- a processor; and
 a memory having program instructions stored thereon and coupled to the processor, wherein when the program instructions are executed by the processor, the processor executes the adaptive control method of any one of claims 1 to 8.
18. An excavator, comprising the electronic device of claim 17.
19. A computer-readable storage medium having program instructions stored thereon, wherein when the program instructions are executed by a processor, the processor executes the adaptive control method of any one of claims 1 to 8.
20. A computer program product, comprising computer programs, wherein when the computer programs are executed by a processor, the processor executes the adaptive control method of any one of claims 1 to 8.

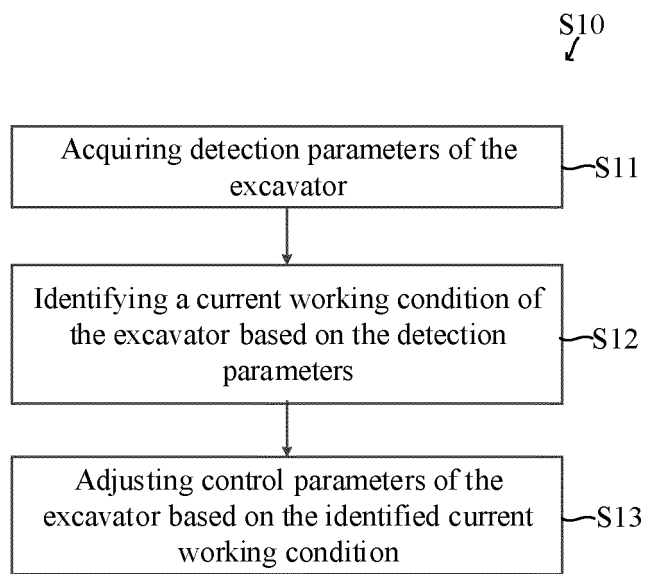


FIG. 1

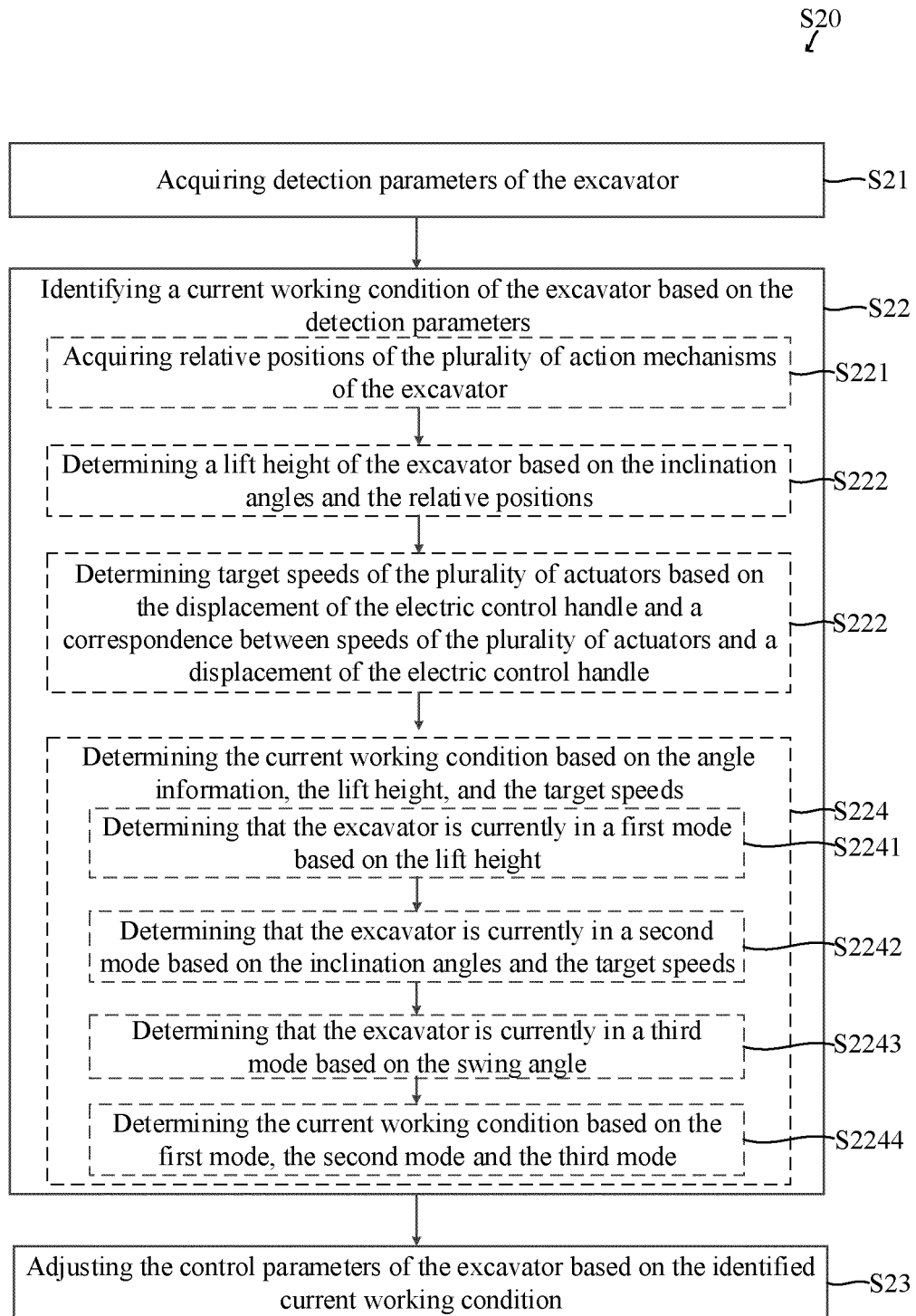


FIG. 2

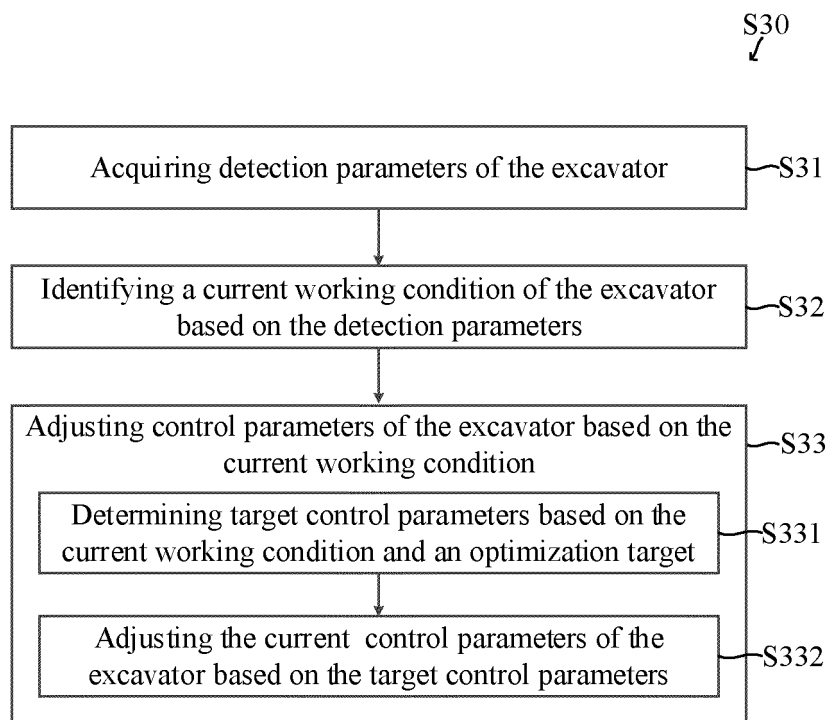


FIG. 3

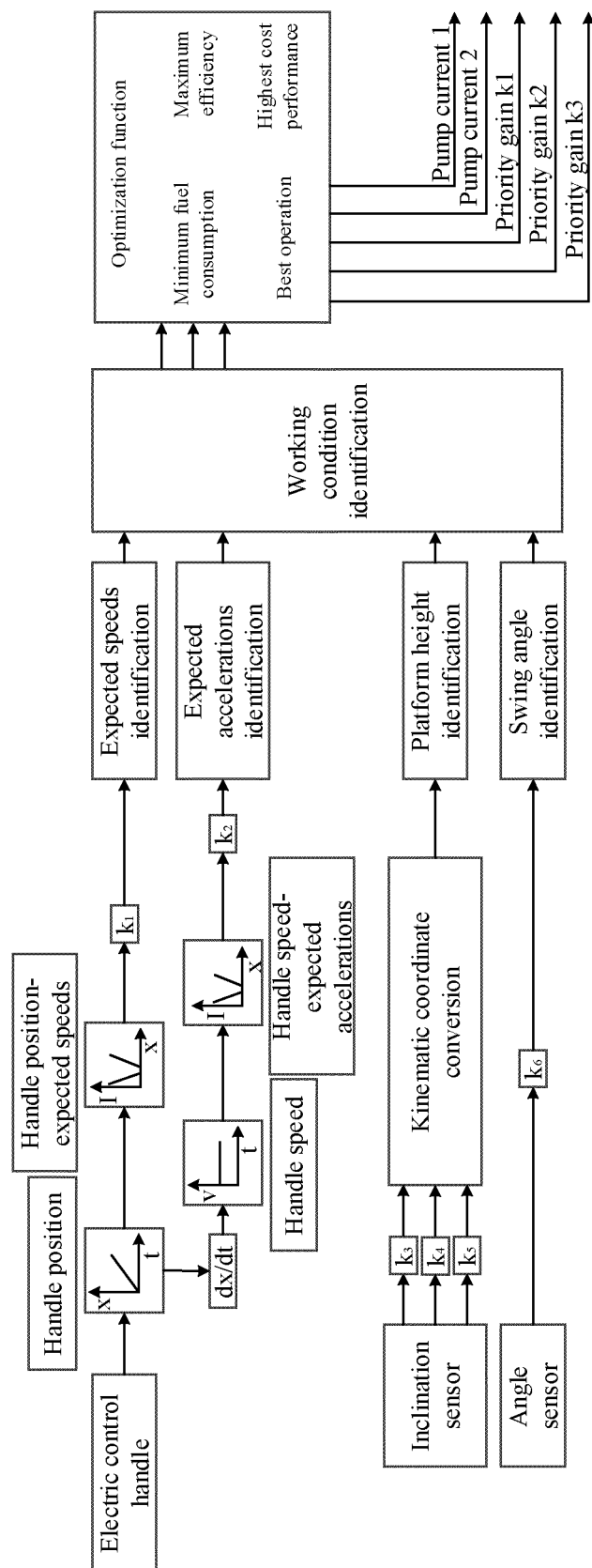


FIG. 4

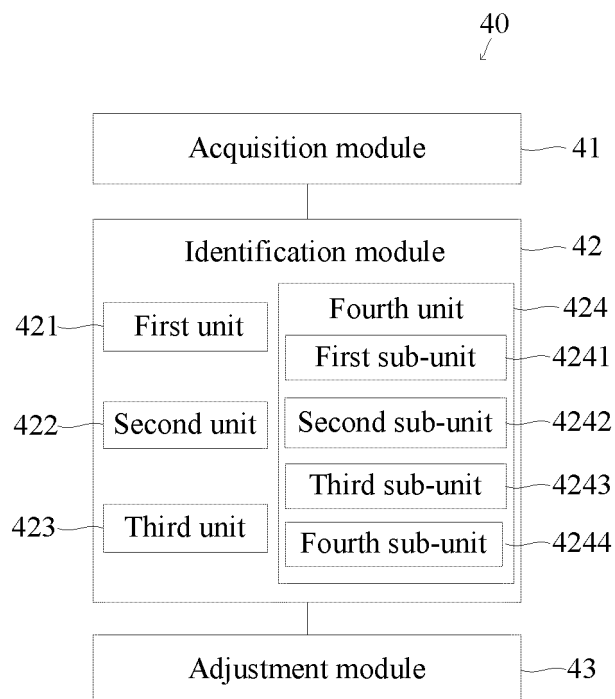


FIG. 5

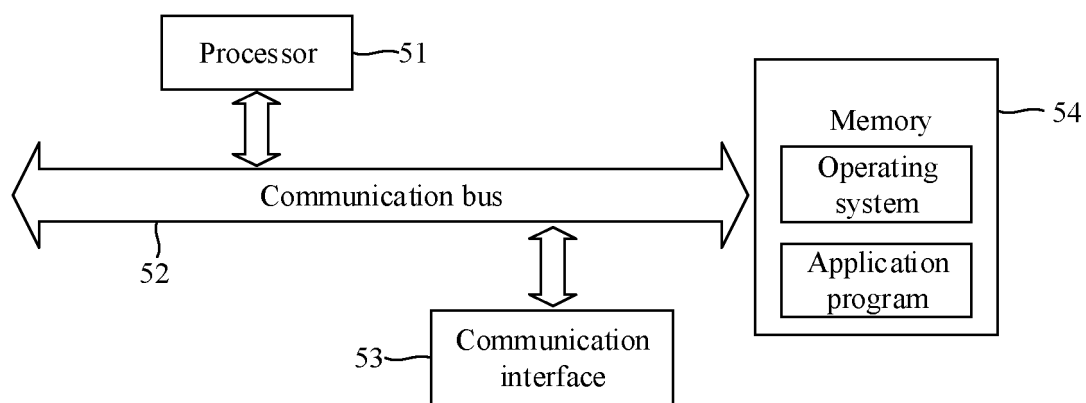


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/078485

A. CLASSIFICATION OF SUBJECT MATTER E02F 9/20(2006.01)i; E02F 9/22(2006.01)i; E02F 3/04(2006.01)i 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) E02F9; E02F3 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) CNABS; CNTXT; CNKI; VEN; USTXT; WOTXT; EPTXT: 三一重机有限公司, 自适应, 挖掘机, 工况, 手柄, 角度, 高度, 速度, 搭台, 举升, 平地, 装车, 甩方, adaptive, excavator?, digger?, mode, joystick?, angle, height, speed, lift+, level+, load+, dump+																		
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>PX</td> <td>CN 113216311 A (SANY HEAVY MACHINERY CO., LTD.) 06 August 2021 (2021-08-06) claims 1-10, description, paragraphs [0058]-[0154]</td> <td>1-20</td> </tr> <tr> <td>Y</td> <td>CN 110905034 A (SANY HEAVY MACHINERY CO., LTD.) 24 March 2020 (2020-03-24) description, paragraphs [0050]-[0068], and figures 1 and 2</td> <td>1, 8, 9, 16-20</td> </tr> <tr> <td>Y</td> <td>CN 111441416 A (JINHUA SHENLIAN NETWORK TECHNOLOGY CO., LTD.) 24 July 2020 (2020-07-24) description, paragraphs [0063]-[0274]</td> <td>1, 8, 9, 16-20</td> </tr> <tr> <td>A</td> <td>CN 112734246 A (SHANGHAI HUAXING DIGITAL TECHNOLOGY CO., LTD.) 30 April 2021 (2021-04-30) entire document</td> <td>1-20</td> </tr> <tr> <td>A</td> <td>US 2016003171 A1 (CATERPILLAR, INC.) 07 January 2016 (2016-01-07) entire document</td> <td>1-20</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	PX	CN 113216311 A (SANY HEAVY MACHINERY CO., LTD.) 06 August 2021 (2021-08-06) claims 1-10, description, paragraphs [0058]-[0154]	1-20	Y	CN 110905034 A (SANY HEAVY MACHINERY CO., LTD.) 24 March 2020 (2020-03-24) description, paragraphs [0050]-[0068], and figures 1 and 2	1, 8, 9, 16-20	Y	CN 111441416 A (JINHUA SHENLIAN NETWORK TECHNOLOGY CO., LTD.) 24 July 2020 (2020-07-24) description, paragraphs [0063]-[0274]	1, 8, 9, 16-20	A	CN 112734246 A (SHANGHAI HUAXING DIGITAL TECHNOLOGY CO., LTD.) 30 April 2021 (2021-04-30) entire document	1-20	A	US 2016003171 A1 (CATERPILLAR, INC.) 07 January 2016 (2016-01-07) entire document	1-20
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<table border="1"> <tr> <td> * 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 </td> <td> “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 </td> </tr> <tr> <td> Date of the actual completion of the international search 19 April 2022 </td> <td> Date of mailing of the international search report 19 May 2022 </td> </tr> <tr> <td> Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China Facsimile No. (86-10)62019451 </td> <td> Authorized officer Telephone No. </td> </tr> </table>	* 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 19 April 2022	Date of mailing of the international search report 19 May 2022	Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China Facsimile No. (86-10)62019451	Authorized officer Telephone No.												
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Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/078485

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Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	113216311	A	06 August 2021	None			
CN	110905034	A	24 March 2020	None			
CN	111441416	A	24 July 2020	None			
CN	112734246	A	30 April 2021	None			
US	2016003171	A1	07 January 2016	US	9469972	B2	18 October 2016