

SPREADER TILTING CONTROL APPARATUS AND CRANE

TECHNICAL FIELD

[0001] The present disclosure relates to a spreader tilting control apparatus, a crane, a spreader tilting control method, an electronic device, and a computer-readable storage medium.

5 BACKGROUND

[0002] In a conventional heavy object hoisting technology, when a hoisting device (such as a crane, a heavy hoisting device or a lifting device) lifts an object to be hoisted (such as a container), a spreader generally needs to be lowered to a suitable height first. In some complicated cases, when the spreader is lowered, a holder on the spreader for fixing the object to be hoisted may not be directly aligned with
10 a hoisting interface of the object to be hoisted, and thus a tilt angle of the spreader needs to be adjusted to make the holder align the hoisting interface of the object to be hoisted.

[0003] However, a traditional spreader tilting control system cannot accurately determine a real-time tilt angle of the spreader, which brings obstacles to alignment of the spreader and the object to be hoisted.

SUMMARY

15 [0004] An embodiment of the present disclosure provides a spreader tilting control apparatus. The spreader tilting control apparatus includes: a spreader; at least one lifting mechanism, where each lifting mechanism has a lifting end connected to the spreader, and each lifting mechanism adjusts a tilt angle of the spreader by adjusting a height of the lifting end; a stroke measurement module, configured to directly or indirectly measure a height change value of the lifting end of each lifting mechanism in
20 real time; and a processing module, configured to receive the height change value, measured by the stroke measurement module, of the lifting end of each lifting mechanism, and determine an actual tilt angle of the spreader based on the height change value.

[0005] In some embodiments, the spreader tilting control apparatus further includes a control module. The control module is configured to: control, based on an adjustment instruction, the at least one lifting
25 mechanism to adjust the height of the lifting end, so as to adjust the tilt angle of the spreader; determine whether the actual tilt angle is the same as the tilt angle that is corresponding to the adjustment instruction; and in response to the actual tilt angle being different from the tilt angle that is corresponding to the adjustment instruction, control the at least one lifting mechanism to adjust the height of the lifting end until the actual tilt angle is the same as the tilt angle that is corresponding to
30 the adjustment instruction.

[0006] In some embodiments, the at least one lifting mechanism includes: a first lifting mechanism, including a first push-pull device and a first flexible pull member, where the first flexible pull member is connected to one end of a pull rod of the first push-pull device, and the first push-pull device is configured to pull the first flexible pull member to adjust a height of a lifting end of the first lifting mechanism; and a second lifting mechanism, including the first push-pull device and a second flexible pull member, where the second flexible pull member is connected to the other end of the first push-pull device, and the first push-pull device is further configured to pull the second flexible pull member to adjust a height of a lifting end of the second lifting mechanism.

[0007] In some embodiments, the at least one lifting mechanism further includes: a third lifting mechanism, including a second push-pull device and a third flexible pull member, where the second push-pull device is configured to pull the third flexible pull member to adjust a height of a lifting end of the third lifting mechanism; and a fourth lifting mechanism, including a third push-pull device and a fourth flexible pull member, where the third push-pull device is configured to pull the fourth flexible pull member to adjust a height of a lifting end of the fourth lifting mechanism.

[0008] In some embodiments, the first lifting mechanism further includes a first direction changing mechanism, the first direction changing mechanism is located between the first push-pull device and the spreader, the first flexible pull member is wound on the first direction changing mechanism, and the first direction changing mechanism is configured to change a force application direction of the first flexible pull member. The second lifting mechanism further includes a second direction changing mechanism, the second direction changing mechanism is located between the first push-pull device and the spreader, the second flexible pull member is wound on the second direction changing mechanism, and the second direction changing mechanism is configured to change a force application direction of the second flexible pull member. The third lifting mechanism further includes a third direction changing mechanism, the third direction changing mechanism is located between the second push-pull device and the spreader, the third flexible pull member is wound on the third direction changing mechanism, and the third direction changing mechanism is configured to change a force application direction of the third flexible pull member. The fourth lifting mechanism further includes a fourth direction changing mechanism, the fourth direction changing mechanism is located between the third push-pull device and the spreader, the fourth flexible pull member is wound on the fourth direction changing mechanism, and the fourth direction changing mechanism is configured to change a force application direction of the fourth flexible pull member.

[0009] In some embodiments, the lifting end of the first lifting mechanism, the lifting end of the second lifting mechanism, the lifting end of the third lifting mechanism, and the lifting end of the fourth lifting mechanism are distributed in a quadrilateral, and the lifting end of the first lifting mechanism and the lifting end of the second lifting mechanism are respectively located at two opposite vertices of the

quadrilateral.

[0010] In some embodiments, a portion, located between the first direction changing mechanism and the first push-pull device, of the first flexible pull member is collinear with a portion, located between the second direction changing mechanism and the first push-pull device, of the second flexible pull member.

[0011] In some embodiments, the first lifting mechanism further includes a first auxiliary direction changing mechanism, the first auxiliary direction changing mechanism is located between the first direction changing mechanism and the first push-pull device, the first flexible pull member is wound on the first auxiliary direction changing mechanism, and the first auxiliary direction changing mechanism is configured to change the force application direction of the first flexible pull member. The second lifting mechanism further includes a second auxiliary direction changing mechanism, the second auxiliary direction changing mechanism is located between the second direction changing mechanism and the first push-pull device, the second flexible pull member is wound on the second auxiliary direction changing mechanism, and the second auxiliary direction changing mechanism is configured to change the force application direction of the second flexible pull member. The third lifting mechanism further includes a third auxiliary direction changing mechanism, the third auxiliary direction changing mechanism is located between the third direction changing mechanism and the second push-pull device, the third flexible pull member is wound on the third auxiliary direction changing mechanism, and the third auxiliary direction changing mechanism is configured to change the force application direction of the third flexible pull member. The fourth lifting mechanism further includes a fourth auxiliary direction changing mechanism, the fourth auxiliary direction changing mechanism is located between the fourth direction changing mechanism and the third push-pull device, the fourth flexible pull member is wound on the fourth auxiliary direction changing mechanism, and the fourth auxiliary direction changing mechanism is configured to change the force application direction of the fourth flexible pull member.

[0012] In some embodiments, a portion, located between the first auxiliary direction changing mechanism and the first push-pull device, of the first flexible pull member is collinear with a portion, located between the second auxiliary direction changing mechanism and the first push-pull device, of the second flexible pull member.

[0013] In some embodiments, one end of the first flexible pull member is connected to the first push-pull device, the other end is connected to the spreader, and the lifting end of the first lifting mechanism is the end, connected to the spreader, of the first flexible pull member. One end of the second flexible pull member is connected to the first push-pull device, the other end is connected to the spreader, and the lifting end of the second lifting mechanism is the end, connected to the spreader, of the second flexible pull member. One end of the third flexible pull member is connected to the second push-pull

device, the other end is connected to the spreader, and the lifting end of the third lifting mechanism is the end, connected to the spreader, of the third flexible pull member. One end of the fourth flexible pull member is connected to the third push-pull device, the other end is connected to the spreader, and the lifting end of the fourth lifting mechanism is the end, connected to the spreader, of the fourth flexible pull member.

[0014] In some embodiments, the spreader tilting control apparatus further includes a pull member fixing mechanism. The first lifting mechanism further includes a first hoisting pulley, and the first hoisting pulley is assembled to the spreader. One end of the first flexible pull member is connected to the pull member fixing mechanism, and the other end goes around the first hoisting pulley and is connected to the first push-pull device. The lifting end of the first lifting mechanism is a portion, connected to the spreader, of the first hoisting pulley. The second lifting mechanism further includes a second hoisting pulley, and the second hoisting pulley is assembled to the spreader. One end of the second flexible pull member is connected to the pull member fixing mechanism, and the other end goes around the second hoisting pulley and is connected to the first push-pull device. The lifting end of the second lifting mechanism is a portion, connected to the spreader, of the second hoisting pulley. The third lifting mechanism further includes a third hoisting pulley, and the third hoisting pulley is assembled to the spreader. One end of the third flexible pull member is connected to the pull member fixing mechanism, and the other end goes around the third hoisting pulley and is connected to the second push-pull device. The lifting end of the third lifting mechanism is a portion, connected to the spreader, of the third hoisting pulley. The fourth lifting mechanism further includes a fourth hoisting pulley, and the fourth hoisting pulley is assembled to the spreader. One end of the fourth flexible pull member is connected to the pull member fixing mechanism, and the other end goes around the fourth hoisting pulley and is connected to the third push-pull device. The lifting end of the fourth lifting mechanism is a portion, connected to the spreader, of the fourth hoisting pulley.

[0015] In some embodiments, the spreader tilting control apparatus further includes a first flexible safety pull member and a second flexible safety pull member. One end of the first flexible safety pull member is connected to the first flexible pull member, and the other end is connected to the second flexible pull member. One end of the second flexible safety pull member is connected to the third flexible pull member, and the other end is connected to the fourth flexible pull member.

[0016] In some embodiments, the stroke measurement module includes: a first set of laser ranging system, including a first laser range finder and a first marker, where the first laser range finder is fixed to the first push-pull device, the first marker is fixed to one of a push-pull end of the first push-pull device, the first flexible pull member, and the second flexible pull member, and a ranging laser of the first laser range finder is irradiated on the first marker to measure a position change value of the first marker, so as to measure a height change value of the lifting end of each of the first lifting mechanism

and the second lifting mechanism; a second set of laser ranging system, including a second laser range finder and a second marker, where the second laser range finder is fixed to the second push-pull device, the second marker is fixed to a push-pull end of the second push-pull device or on the third flexible pull member, and a ranging laser of the second laser range finder is irradiated on the second marker to measure a position change value of the second marker, so as to measure a height change value of the lifting end of the third lifting mechanism; and a third set of laser ranging system, including a third laser range finder and a third marker, where the third laser range finder is fixed to the third push-pull device, the third marker is fixed to a push-pull end of the third push-pull device or on the fourth flexible pull member, and a ranging laser of the third laser range finder is irradiated on the third marker to measure a position change value of the third marker, so as to measure a height change value of the lifting end of the fourth lifting mechanism.

[0017] In some embodiments, the first push-pull device includes a double-headed push-pull rod. The double-headed push-pull rod is connected to the first flexible pull member and the second flexible pull member respectively through fixed sliders at both ends of the double-headed push-pull rod. Each fixed slider at both ends of the double-headed push-pull rod is slidably assembled on a corresponding sliding seat, and the first marker is fixed to a fixed slider at one end of the double-headed push-pull rod. The second push-pull device and the third push-pull device are respectively connected to the third flexible pull member and the fourth flexible pull member through a fixed slider at an end of respective push-pull rods. A fixed slider at an end of the push-pull rod of each of the second push-pull device and the third push-pull device is slidably assembled on a corresponding sliding seat. The second marker and the third marker are respectively fixed to the fixed sliders at the end of the push-pull rods of the second push-pull device and the third push-pull device.

[0018] An embodiment of the present disclosure further provides a crane. The crane includes the spreader tilting control apparatus provided in any one of the foregoing embodiments.

[0019] According to the embodiment of the present disclosure, a height of each fixed point of a spreader is controlled by controlling at least one lifting mechanism, thereby implementing tilting control of the spreader. In addition, a stroke measurement module is used to directly or indirectly monitor a height change value of a lifting end of each lifting mechanism in real time, and the height change value of each lifting end is the height change value of each fixed point of the spreader. A processing module may learn change of the tilt angle of the spreader through various existing tilt angle calculation methods. When the spreader reaches a tilt angle that can be allowed to fit a holder on an object to be hoisted, an operation of the lifting mechanism is stopped and the holder is fitted on the object to be hoisted. After the change of the tilt angle is learned, it may be used for various purposes. For example, the real-time tilt angle of the spreader may be displayed for an operator in real time, and the operator may learn tilting status of the spreader in real time

according to the displayed real-time tilt angle. It may also be used directly as feedback data. For example, when an operator wants to control the lifting mechanism to make the spreader reach a specific angle, the operator only needs to view the real-time tilt angle obtained by the processing module, and constantly adjust one or more lifting mechanisms to achieve a desired tilt angle.

5 BRIEF DESCRIPTION OF DRAWINGS

[0020] FIG. 1 is a schematic structural diagram of a spreader tilting control apparatus according to an embodiment of the present disclosure.

[0021] FIG. 2 is a schematic diagram illustrating a calculation principle of a tilt angle of a spreader according to an embodiment of the present disclosure.

10 [0022] FIG. 3 is a schematic structural diagram of a spreader tilting control apparatus according to another embodiment of the present disclosure.

[0023] FIG. 4 is a schematic structural diagram of a part of a spreader tilting control apparatus according to another embodiment of the present disclosure.

15 [0024] FIG. 5 is a schematic structural diagram of a spreader tilting control apparatus according to another embodiment of the present disclosure.

[0025] FIG. 6 is a schematic structural diagram of a spreader tilting control apparatus according to another embodiment of the present disclosure.

[0026] FIG. 7 is a schematic structural diagram of a spreader tilting control apparatus according to another embodiment of the present disclosure.

20 [0027] FIG. 8 is a schematic structural diagram of a part of a spreader tilting control apparatus according to another embodiment of the present disclosure.

[0028] FIG. 9 is a schematic flowchart of a spreader tilting control method according to an embodiment of the present disclosure.

25 [0029] FIG. 10 is a schematic flowchart of a spreader tilting control method according to another embodiment of the present disclosure.

[0030] FIG. 11 is a schematic structural diagram of an electronic device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

30 [0031] The embodiments of the present disclosure are described below clearly and completely with reference to the accompanying drawings. Apparently, the described embodiments are some rather than all of the embodiments of the present disclosure.

[0032] FIG. 1 shows a spreader tilting control apparatus according to an embodiment of the

present disclosure.

[0033] Referring to FIG. 1, the spreader tilting control apparatus includes a spreader 20, at least one lifting mechanism 100, a stroke measurement module 500 and a processing module 600. In some embodiments, the spreader 20 is equipped with a plurality of holders 29 for fixing an object to be hoisted.

[0034] It should be understood that at least one refers to one or more. In other words, in some embodiments, the spreader tilting control apparatus may include only one lifting mechanism 100, while in some other embodiments, the spreader tilting apparatus may include a plurality of the lifting mechanisms 100.

[0035] The lifting mechanism 100 has a lifting end 100a connected to the spreader 20. The lifting mechanism 100 adjusts a tilt angle of the spreader 20 by adjusting a height of the lifting end 100a. The stroke measurement module 500 is configured to directly or indirectly measure a height change value of the lifting end 100a in real time. The processing module 600 is configured to receive the height change value of the lifting end 100a measured by the stroke measurement module 500, and calculate an actual tilt angle of the spreader 20 based on the height change value of the lifting end 100a.

[0036] According to the embodiment of the present disclosure, a tilt angle of a spreader is controlled by controlling at least one lifting mechanism, thereby implementing tilting control of the spreader. In addition, a stroke measurement module is used to directly or indirectly monitor a height change value of a lifting end, connected to the spreader, of the at least one lifting mechanism in real time, and a processing module is used for calculation based on the height change value, so that changes of the tilt angle of the spreader may be accurately determined. In this way, when the spreader reaches a tilt angle at which a holder can be fitted to an object to be hoisted, an operation of the lifting mechanism may be stopped to allow the holder to be fitted to the object to be hoisted.

[0037] After the changes of the tilt angle of the spreader is determined, the changes may be displayed to an operator, so that the operator can learn tilting status of the spreader in real time. When the lifting mechanism needs to be controlled to adjust the tilt angle of the spreader to a target angle, the operator may adjust, based on a real-time tilt angle of the spreader obtained by the processing module, one or more lifting mechanisms to adjust the tilt angle of the spreader to the target angle.

[0038] In an implementation, various types of range finders, such as a laser range finder, may be selected as the stroke measurement module. In the embodiment in which the stroke measurement module is a laser range finder, a detection laser of the laser range finder may be shone on a lifting end of a lifting mechanism, so as to directly detect a height change value of the lifting end. After

a height change value of a lifting end of at least one lifting mechanism is determined, the real-time tilt angle of the spreader may be determined.

[0039] In some embodiments, referring to FIG. 1 again, there may be four lifting mechanisms 100, and lifting ends 100a of the four lifting mechanisms 100 are arranged to define a quadrilateral shape, such as a rectangular shape.

[0040] According to the embodiment of the present disclosure, since fixed points of the lifting ends of the four lifting mechanisms on the spreader form a quadrilateral, it is more convenient to calculate the tilt angle of the spreader.

[0041] It should be understood that there are various ways to calculate the tilt angle of the spreader, and the embodiment of the present disclosure does not specifically limit how to calculate the tilt angle of the spreader.

[0042] FIG. 2 is a schematic diagram illustrating a calculation principle of a tilt angle of a spreader according to an embodiment of the present disclosure.

[0043] Referring to FIG. 2, in this embodiment, positions of lifting ends of two adjacent lifting mechanisms descend synchronously, and positions of lifting ends of the other two adjacent lifting mechanisms remain unchanged.

[0044] Although no lifting mechanism is shown in FIG. 2, it can be understood that the two lifting mechanisms with lifting ends lowered are located at the right end of the spreader 20, and the two lifting mechanisms with lifting ends remain unchanged are located at the left end of the spreader 20.

[0045] A tilt angle of the spreader 20 may be calculated by using a trigonometric function. If h is used as an absolute value of a descending height of two lifting ends with positions lowered synchronously (a difference in the horizontal height before and after the two lifting ends descend), and s is a distance between the descending lifting ends and the unchanged lifting ends, the tilt angle of the spreader is $\arcsin(h/s)$.

[0046] Similarly, when a horizontal height of one lifting end is lower than horizontal heights of the other three lifting ends, h may be used as a descending height value of the lowest lifting end, and s may be used as a distance between the lowest lifting end and the highest lifting end. According to the foregoing formula $\arcsin(h/s)$, the tilt angle of the spreader may be calculated.

[0047] It should be noted that, in actual application, it is common for two adjacent lifting ends to descend synchronously and the other two adjacent lifting ends to remain relatively unchanged.

[0048] In an embodiment, referring to FIG. 1 again, the spreader tilting control apparatus further includes a control module 700. The control module 700 is configured to: control, based on an adjustment instruction, at least one lifting mechanism 100 to adjust a height of the lifting end 100a, so as to adjust the tilt angle of the spreader 20; determine whether the actual tilt angle

calculated by the processing module 600 is the same as the tilt angle (namely, a target tilt angle) that is corresponding to the adjustment instruction; and in response to the actual tilt angle calculated by the processing module 600 being different from the tilt angle that is corresponding to the adjustment instruction, control one or more lifting mechanisms 100 to adjust the heights of
5 respective lifting ends 100a until the actual tilt angle calculated by the processing module 600 is the same as the tilt angle that is corresponding to the adjustment instruction.

[0049] That is to say, the control module 700 can compare the actual tilt angle calculated by the processing module 600 with the tilt angle that is corresponding to the adjustment instruction. If the two tilt angles are different, the control module 700 controls a plurality of lifting mechanisms
10 100 to adjust the tilt angle of the spreader 20 again. If the two tilt angles are the same, the control module 700 stops adjusting the tilt angle of the spreader 20.

[0050] In the embodiment of the present disclosure, the adjustment instruction may be issued by an operator or by a computer. The adjustment instruction may include a target tilt angle of the spreader. The control module compares an actual tilt angle calculated by a processing module
15 with a target tilt angle that is corresponding to the adjustment instruction. If the two tilt angles are different, a feedback control signal is continuously sent to a lifting mechanism by using a feedback control algorithm, so that the lifting mechanism continuously adjusts a height of a lifting end of at least one lifting mechanism, and an accurate tilt operation is completed until the actual tilt angle is the same as the target tilt angle that is corresponding to the adjustment instruction.

[0051] As an example, in some specific application scenarios, an operator may issue an adjustment instruction by manipulating a mechanical device such as a joystick. Based on the adjustment instruction, the control module controls operation of the lifting mechanism, and then the control module automatically performs feedback control, so that the spreader finally reaches a tilt angle that is corresponding to the adjustment instruction.

[0052] FIG. 3 is a schematic structural diagram of a spreader tilting control apparatus according to another embodiment of the present disclosure.

[0053] In some embodiments, referring to FIG. 3, a spreader tilting control apparatus may include a first lifting mechanism, a second lifting mechanism, a third lifting mechanism and a fourth lifting mechanism.

[0054] The first lifting mechanism may include a first direction changing mechanism 8, a first push-pull device 101 and a first flexible pull member 3. The first direction changing mechanism 8 is configured to change a pulling direction for pulling a spreader 20. The first push-pull device 101 is configured to pull the spreader 20 to adjust a tilt angle of the spreader 20. One end of the first flexible pull member 3 is fixed to the spreader 20, and the other end goes around the first
35 direction changing mechanism 8 and is connected to a push-pull end of the first push-pull device

101 (namely, one end of a telescopic member of the first push-pull device 101).

[0055] In other words, the first push-pull device 101 is configured to pull the first flexible pull member 3 to adjust a height of a lifting end of the first lifting mechanism, so as to pull the spreader 20 to adjust the tilt angle of the spreader 20. The first direction changing mechanism 8 is located
5 between the first push-pull device 101 and the spreader 20, and the first flexible pull member 3 is wound on the first direction changing mechanism 8. The first direction changing mechanism 8 is configured to change a force application direction of the first flexible pull member 3.

[0056] The second lifting mechanism may include a second direction changing mechanism 10, a first push-pull device 101 and a second flexible pull member 4. That is to say, the first lifting
10 mechanism and the second lifting mechanism share the first push-pull device 101. The second direction changing mechanism 10 is configured to change a pulling direction for pulling the spreader 20. The first push-pull device 101 is configured to pull the spreader 20 to adjust the tilt angle of the spreader 20. One end of the second flexible pull member 4 is fixed to the spreader 20, and the other end goes around the second direction changing mechanism 10 and is connected
15 to a push-pull end of the first push-pull device 101 (namely, the other end of the telescopic member of the first push-pull device 101).

[0057] In other words, the first push-pull device 101 is further configured to pull the second flexible pull member 4 to adjust a height of a lifting end of the second lifting mechanism, so as to pull the spreader 20 to adjust the tilt angle of the spreader 20. The second direction changing
20 mechanism 10 is located between the first push-pull device 101 and the spreader 20, and the second flexible pull member 4 is wound on the second direction changing mechanism 10. The second direction changing mechanism 10 is configured to change a force application direction of the second flexible pull member 4.

[0058] The third lifting mechanism includes a third direction changing mechanism 12, a second
25 push-pull device 102 and a third flexible pull member 5. The third direction changing mechanism 12 is configured to change the pulling direction for pulling the spreader 20. The second push-pull device 102 is configured to pull the spreader 20 to adjust the tilt angle of the spreader 20. One end of the third flexible pull member 5 is fixed to the spreader 20, and the other end goes around the third direction changing mechanism 12 and is connected to a push-pull end of the second
30 push-pull device 102 (namely, one end of a telescopic member of the second push-pull device 102).

[0059] In other words, the second push-pull device 102 is configured to pull the third flexible pull member 5 to adjust a height of a lifting end of the third lifting mechanism, so as to pull the spreader 20 to adjust the tilt angle of the spreader 20. The third direction changing mechanism
35 12 is located between the second push-pull device 102 and the spreader 20, and the third flexible

pull member 5 is wound on the third direction changing mechanism 12. The third direction changing mechanism 12 is configured to change a force application direction of the third flexible pull member 5.

[0060] The fourth lifting mechanism includes a fourth direction changing mechanism 14, a third push-pull device 103 and a fourth flexible pull member 6. The fourth direction changing mechanism 14 is configured to change the pulling direction for pulling the spreader 20. The third push-pull device 103 is configured to pull the spreader 20 to adjust the tilt angle of the spreader 20. One end of the fourth flexible pull member 6 is fixed to the spreader 20, and the other end goes around the fourth direction changing mechanism 14 and is connected to a push-pull end of the third push-pull device 103 (namely, one end of a telescopic member of the third push-pull device 103).

[0061] In other words, the third push-pull device 103 is configured to pull the fourth flexible pull member 6 to adjust a height of a lifting end of the fourth lifting mechanism, so as to pull the spreader 20 to adjust the tilt angle of the spreader 20. The fourth direction changing mechanism 14 is located between the third push-pull device 103 and the spreader 20, and the fourth flexible pull member 6 is wound on the fourth direction changing mechanism 14. The fourth direction changing mechanism 14 is configured to change a force application direction of the fourth flexible pull member 6.

[0062] In this embodiment, the first flexible pull member 3, the second flexible pull member 4, the third flexible pull member 5 and the fourth flexible pull member 6 are all fixedly connected to the spreader 20. Therefore, in this embodiment, the lifting end of the first lifting mechanism is an end, connected to the spreader 20, of the first flexible pull member 3; the lifting end of the second lifting mechanism is an end, connected to the spreader 20, of the second flexible pull member 4; the lifting end of the third lifting mechanism is an end, connected to the spreader 20, of the third flexible pull member 5; and the lifting end of the fourth lifting mechanism is an end, connected to the spreader 20, of the fourth flexible pull member 6.

[0063] In some embodiments, connection points of the first flexible pull member 3, the second flexible pull member 4, the third flexible pull member 5 and the fourth flexible pull member 6 on the spreader 20 form a quadrilateral with each other, and the connection points of the first flexible pull member 3 and the second flexible pull member 4 on the spreader 20 are two diagonal points of the quadrilateral. In this way, the lifting ends of the four lifting mechanisms may be distributed in a quadrilateral, and the lifting ends of the first lifting mechanism and the second lifting mechanism are located at two opposite fixed points of the quadrilateral.

[0064] In some embodiments, the first direction changing mechanism 8, the second direction changing mechanism 10, the third direction changing mechanism 12 and the fourth direction

changing mechanism 14 are all located above the spreader 20 and form a quadrilateral with each other. A section, of the first flexible pull member 3, connected to the push-pull end of the first push-pull device 101 after the first flexible pull member 3 goes around the first direction changing mechanism 8 and a section, of the second flexible pull member 4, connected to the push-pull end of the first push-pull device 101 after the second flexible pull member 4 goes around the second direction changing mechanism 10 are collinear with each other. That is to say, a portion, of the first flexible pull member 3, located between the first direction changing mechanism 8 and the first push-pull device 101 is partially collinear with a portion, of the second flexible pull member 4, located between the second direction changing mechanism 10 and the first push-pull device 101.

[0065] FIG. 4 is a schematic structural diagram of a part of a spreader tilting control apparatus according to another embodiment of the present disclosure.

[0066] In some embodiments, referring to FIG. 4, the stroke measurement module may include three sets of laser measurement systems.

[0067] The first set of laser ranging system includes a first laser range finder 201 and a first marker 202. The first laser range finder 201 is fixed to the first push-pull device 101. The first marker 202 may be fixed to a push-pull end of the first push-pull device 101, or may be fixed to the first flexible pull member 3, or may be fixed to the second flexible pull member 4. A ranging laser of the first laser range finder 201 is irradiated on the first marker 202 to measure a position change value of the first marker 202.

[0068] The second set of laser ranging system includes a second laser range finder 301 and a second marker 302. The second laser range finder 301 is fixed to the second push-pull device 102. The second marker 302 may be fixed to a push-pull end of the second push-pull device 102, or may be fixed to the third flexible pull member 5. A ranging laser of the second laser range finder 301 is irradiated on the second marker 302 to measure a position change value of the second marker 302.

[0069] The third set of laser ranging system includes a third laser range finder 401 and a third marker 402. The third laser range finder 401 is fixed to the third push-pull device 103. The third marker 402 is fixed to a push-pull end of the third push-pull device 103, or may be fixed to the fourth flexible pull member 6. A ranging laser of the third laser range finder 401 is irradiated on the third marker 402 to measure a position change value of the third marker 302.

[0070] In some embodiments, the processing module may be further configured to: receive position change values, measured by first, second, and third sets of laser range finders, of the first, second, and third markers; calculate, by using a preset algorithm, an actual tilt angle of a spreader based on the position change values of the markers; and decompose an adjustment

instruction into independent control instructions for first, second and third push-pull devices.

[0071] The control module may be further configured to: control the first, second and third push-pull devices based on the independent control instructions, to control height values of fixed points of first, second, third and fourth flexible pull members on the spreader, so as to control a tilt angle of the spreader.

[0072] According to the embodiment of the present disclosure, four flexible pull members are used to pull four corners of the spreader for tilt control, and a push-pull device (namely, the first push-pull device) is used to simultaneously pull a first flexible pull member and a second flexible pull member, which can reduce a device and simplify a structure.

[0073] In some embodiments, referring to FIG. 4 again, the first push-pull device 101 may realized as a device such as a linear actuator with a double-headed push-pull rod. Two ends of a double-headed push-pull rod of the linear actuator are respectively connected to the first flexible pull member 3 and the second flexible pull member 4. When the linear actuator pulls the first flexible pull member 3 towards itself, the second flexible pull member 4 goes far away from the linear actuator. When the first push-pull device 101 pulls the first flexible pull member 3, the second flexible pull member 4 is correspondingly lowered, that is, a fixed point of the first flexible pull member 3 on the spreader 20 is lifted, and a fixed point of the second flexible pull member 4 on the spreader 20 is lowered. In this case, the spreader 20 implements tilting action. In addition, the second push-pull device 102 may be cooperated to control lifting and lowering of a fixed point of the third flexible pull member 5 on the spreader 20. In addition, the third push-pull device 103 may be cooperated to control lifting and lowering of a fixed point of the fourth flexible pull member 6 on the spreader 20, so as to implement more complex tilting control in a compound direction. Similarly, if tilting in another direction needs to be performed, for example, if a side where the fixed point corresponding to the second flexible pull member 4 and the fixed point corresponding to the third flexible pull member 5 are located needs to be lifted, and a side where the fixed point corresponding to the first flexible pull member 3 and the fixed point corresponding to the fourth flexible pull member 6 are located needs to be lowered, the first push-pull device 101 is operated to lift the second flexible pull member 4 upward, and the first flexible pull member 3 is correspondingly lowered by the first push-pull device 101, and then the third push-pull device 103 is operated to lower the fourth flexible pull member 6, so as to implement tilting of the spreader in this case. A manner of tilting in other directions is similar, and details are not repeated herein again.

[0074] Only one direction changing mechanism is used to change a moving direction of a flexible pull member, and a push-pull device may control a flexible pull member in another direction through only one direction changing mechanism, which can reduce the structure and save

materials, resulting in a lower failure rate and a simpler structure.

[0075] In some embodiments, all or part of the push-pull devices may be driven by a variable frequency drive. The signal of the variable frequency drive may come from the control module. The linear actuator(s) is driven by the variable frequency drive, which can control the linear
5 actuator more accurately and linearly. In some embodiments, the push-pull device may be realized as a variable-frequency linear actuator, so as to directly implement variable-frequency control. In some embodiments, the variable frequency drive may be communicatively connected or integrated with the control module, so that the control module can more accurately and linearly adjust the tilt angle of the spreader in feedback control.

10 [0076] Through four direction changing mechanisms, directions of lifting motions of fixed points of the flexible pull members on the spreader are converted, so that three push-pull devices may be arranged parallel to the horizontal plane, and the bodies and the push-pull rods may be arranged on a same plane, facilitating set and configuration of a mechanical structure.

[0077] In some embodiments, each flexible pull member may be realized as a wire rope, and each
15 direction changing mechanism may be realized a pulley.

[0078] A first direction changing mechanism, a second direction changing mechanism, a third direction changing mechanism and a fourth direction changing mechanism are all located above the spreader and form a quadrilateral with each other, so that a control method is more concise.

[0079] In some implementations, the four direction changing mechanisms may form a rectangle,
20 four connection points where lifting ends of the four lifting mechanisms are connected to the spreader form a rectangle of a same size, and the rectangle formed by the direction changing mechanisms are located directly above the rectangle formed by the connection points. A section, of a first flexible pull member, connected to a push-pull end of a first push-pull device after the first flexible pull member goes around the first direction changing mechanism and a section, of a
25 second flexible pull member, connected to a push-pull end of the first push-pull device after the second flexible pull member goes around the second direction changing mechanism are collinear with each other. The collinearity makes movement of the two flexible pull members synchronous. If a movement value of one of the flexible pull members is detected, a movement value of the other flexible pull member is the same. Therefore, the collinearity can simplify detection and
30 calculation.

[0080] A laser ranging method can measure a movement distance of a flexible pull member in real time. The first push-pull device drives both the first flexible pull member and the second flexible pull member, and each direction changing mechanism acts as a fixed pulley. Therefore, the lifting distances of the lifting ends of the first lifting mechanism and the second lifting
35 mechanism may be indirectly obtained if only a movement distance of a single end of the first

push-pull device is collected.

[0081] It should be noted that, the straight lines with an arrow in FIG. 4 show approximate optical paths of probe laser light.

[0082] A laser range finder can detect a distance change of a corresponding marker in real time.

5 Each laser range finder and a processing module may be connected in a wired or wireless manner, and a detected position change value of each marker is sent to the processing module. The position change value of each marker is a height change value of each lifting end. Thus, the processing module can calculate change of the tilt angle of the spreader.

10 [0083] When an operator or a computer issues a complex spreader tilting control instruction, the processing module can decompose the control instruction into independent control instructions for the first, second and third push-pull devices. The control module may implement complex control of the tilt angle of the spreader by independently controlling the first, second and third push-pull devices.

15 [0084] In some embodiments, after the spreader performs a tilting action, the spreader may be slightly moved by operating one or more push-pull devices. During slight movement, under the action of gravity, the spreader rotates at an angle, so that a lifting hole of an object to be hoisted may be further easily aligned.

[0085] FIG. 5 is a schematic structural diagram of a spreader tilting control apparatus according to another embodiment of the present disclosure.

20 [0086] In some embodiments, referring to FIG. 5, the first lifting mechanism may further include a first auxiliary direction changing mechanism 7. One end of the first flexible pull member 3 is fixed to the spreader 20, and the other end goes around the first direction changing mechanism 8 and the first auxiliary direction changing mechanism 7 in turn and is then connected to the push-pull end of a first push-pull device 101. That is, the first auxiliary direction changing mechanism
25 7 is located between the first direction changing mechanism 8 and the first push-pull device 101, and the first flexible pull member 3 is wound on the first auxiliary direction changing mechanism 7. The first auxiliary direction changing mechanism 7 is configured to change a force application direction of the first flexible pull member 3.

30 [0087] The second lifting mechanism further includes a second auxiliary direction changing mechanism 9. One end of the second flexible pull member 4 is fixed to the spreader 20, and the other end goes around a second direction changing mechanism 10 and the second auxiliary direction changing mechanism 9 in turn and is then connected to a push-pull end of the first push-pull device 101.

35 [0088] That is to say, the second auxiliary direction changing mechanism 9 is located between the second direction changing mechanism 10 and the first push-pull device 101, and the second

flexible pull member 4 is wound on the second auxiliary direction changing mechanism 9. The second auxiliary direction changing mechanism 9 is configured to change a force application direction of the second flexible pull member 4.

[0089] The third lifting mechanism further includes a third auxiliary direction changing mechanism 11. One end of the third flexible pull member 5 is fixed to the spreader 20, and the other end goes around a third direction changing mechanism 12 and the third auxiliary direction changing mechanism 11 in turn and is then connected to a push-pull end of a second push-pull device 102.

[0090] That is to say, the third auxiliary direction changing mechanism 11 is located between the third direction changing mechanism 12 and the second push-pull device 102, and the third flexible pull member 5 is wound on the third auxiliary direction changing mechanism 11. The third auxiliary direction changing mechanism 11 is configured to change a force application direction of the third flexible pull member 5.

[0091] The fourth lifting mechanism further includes a fourth auxiliary direction changing mechanism 13. One end of the fourth flexible pull member 6 is fixed to the spreader 20, and the other end goes around the fourth direction changing mechanism 14 and the fourth auxiliary direction changing mechanism 13 in turn and is then connected to a push-pull end of a third push-pull device 103.

[0092] That is to say, the fourth auxiliary direction changing mechanism 13 is located between the fourth direction changing mechanism 14 and the third push-pull device 103, and the fourth flexible pull member 6 is wound on the fourth auxiliary direction changing mechanism 13. The fourth auxiliary direction changing mechanism 13 is configured to change a force application direction of the fourth flexible pull member 6.

[0093] In some embodiments, referring to FIG. 5 again, a section, of the first flexible pull member 3, connected to a push-pull end of the first push-pull device 101 after the first flexible pull member 3 goes around the first auxiliary direction changing mechanism 7 and a section, of the second flexible pull member 4, connected to a push-pull end of the first push-pull device 101 after the second flexible pull member 4 goes around the second auxiliary direction changing mechanism 9 are collinear with each other.

[0094] That is to say, a portion, of the first flexible pull member 3, located between the first auxiliary direction changing mechanism 7 and the first push-pull device 101 is collinear with a portion, of the second flexible pull member 4, located between the second auxiliary direction changing mechanism 9 and the first push-pull device 101.

[0095] According to the embodiment of the present disclosure, each push-pull device may not need to be directly above the spreader through the four auxiliary direction changing mechanisms.

Therefore, various types of mechanical device such as a trolley and a crane may be installed on the top of the spreader, and a push-pull device may be set in a far place, so that an assembly space of the push-pull devices may be increased, and only auxiliary direction changing mechanisms and direction changing mechanisms are used for lifting transmission.

5 [0096] It should be understood that both the auxiliary direction changing mechanism and the direction changing mechanism may use a fixed pulley.

[0097] A section, of a first flexible pull member, connected to a push-pull end after the first flexible pull member goes around a first auxiliary direction changing mechanism and a section, of a second flexible pull member, connected to a push-pull end after the second flexible pull member goes around a second auxiliary direction changing mechanism are collinear with each other. A laser range finder detects a telescopic length of one of the first flexible pull member and the second flexible pull member, and a telescopic length of the other one may be directly obtained without any conversion.

10 [0098] FIG. 6 is a schematic structural diagram of a spreader tilting control apparatus according to another embodiment of the present disclosure.

[0099] In some embodiments, referring to FIG. 6, a first lifting mechanism further includes a first hoisting pulley 21, a second lifting mechanism further includes a second hoisting pulley 22, a third lifting mechanism further includes a third hoisting pulley 23, and a fourth lifting mechanism further includes a fourth hoisting pulley 24.

20 [0100] The first hoisting pulley 21, the second hoisting pulley 22, the third hoisting pulley 23 and the fourth hoisting pulley 24 are respectively fixed to four corners of the spreader 20, and the first hoisting pulley 21 and the second hoisting pulley 22 are disposed at two diagonal points. That is to say, the first hoisting pulley 21, the second hoisting pulley 22, the third hoisting pulley 23 and the fourth hoisting pulley 24 enclose a quadrilateral, and the first hoisting pulley 21 and the second hoisting pulley 22 are respectively located at two opposite vertices of the quadrilateral.

25 [0101] The spreader tilting control apparatus may further include a pull member fixing mechanism 40. The pull member fixing mechanism 40 may be fixed relative to the spreader 20.

[0102] One end of a first flexible pull member 3 is connected to the pull member fixing mechanism 40, and the other end goes around the first hoisting pulley 21 and is connected to a first push-pull device 101. One end of a second flexible pull member 4 is connected to the pull member fixing mechanism 40, and the other end goes around the second hoisting pulley 22 and is connected to the first push-pull device 101. One end of a third flexible pull member 5 is connected to the pull member fixing mechanism 40, and the other end goes around the third hoisting pulley 23 and is connected to a second push-pull device 102. One end of a fourth flexible pull member 6 is connected to the pull member fixing mechanism 40, and the other end goes

around the fourth hoisting pulley 24 and is connected to a third push-pull device 103.

[0103] More specifically, one end of the first flexible pull member 3 is fixed to the pull member fixing mechanism 40, and the other end goes around a first direction changing mechanism 8, the first hoisting pulley 21 and a first auxiliary direction changing mechanism 7 in turn and is connected to a push-pull end of the first push-pull device 101. One end of the second flexible pull member 4 is fixed to the pull member fixing mechanism 40, and the other end goes around a second direction changing mechanism 10, the second hoisting pulley 22 and a second auxiliary direction changing mechanism 9 in turn and is connected to a push-pull end of the first push-pull device 101. One end of the third flexible pull member 5 is fixed to the pull member fixing mechanism 40, and the other end goes around a third direction changing mechanism 12, the third hoisting pulley 23 and a third auxiliary direction changing mechanism 11 in turn and is connected to a push-pull end of the second push-pull device 102. One end of the fourth flexible pull member 6 is fixed to the pull member fixing mechanism 40, and the other end goes around a fourth direction changing mechanism 14, the fourth hoisting pulley 24 and a fourth auxiliary direction changing mechanism 13 in turn and is connected to a push-pull end of the third push-pull device 103.

[0104] It should be noted that a lifting end of the first lifting mechanism may be a portion where the first hoisting pulley 21 is connected to the spreader 20, a lifting end of the second lifting mechanism may be a portion where the second hoisting pulley 22 is connected to the spreader 20, a lifting end of the third lifting mechanisms may be a portion where the third hoisting pulley 23 is connected to the spreader 20, and a lifting end of the fourth lifting mechanism may be a portion where the fourth hoisting pulley 24 is connected to the spreader 20.

[0105] In some embodiments, each of the first direction changing mechanism 8, the second direction changing mechanism 10, the third direction changing mechanism 12 and the fourth direction changing mechanism 14 may include a pair of pulleys. One end of the first flexible pull member 3 may be fixed to the pull member fixing mechanism 40, and the other end may go around a pulley of the first direction changing mechanism 8, the first hoisting pulley 21, the other pulley of the first direction changing mechanism 8, and the first auxiliary direction changing mechanism 7 in turn and is then connected to the first push-pull device 101. One end of the second flexible pull member 4 may be fixed to the pull member fixing mechanism 40, and the other end may go around a pulley of the second direction changing mechanism 10, the second hoisting pulley 22, the other pulley of the second direction changing mechanism 10, and the second auxiliary direction changing mechanism 9 in turn and is then connected to the first push-pull device 101. One end of the third flexible pull member 5 may be fixed to the pull member fixing mechanism 40, and the other end may go around a pulley of the third direction changing mechanism 12, the

third hoisting pulley 23, the other pulley of the third direction changing mechanism 12, and the third auxiliary direction changing mechanism 11 in turn and is then connected to the second push-pull device 102. One end of the fourth flexible pull member 6 may be fixed to the pull member fixing mechanism 40, and the other end may go around a pulley of the fourth direction changing mechanism 14, the fourth hoisting pulley 24, the other pulley of the fourth direction changing mechanism 14, and the fourth auxiliary direction changing mechanism 13 in turn and is then connected to the third push-pull device 103.

[0106] Lifting and lowering a spreader by using moving pulleys, such as hoisting pulleys, can save more effort.

[0107] In some embodiments, the pull member fixing mechanism may be a wire coil or the like. When the spreader and a flexible pull member move, the pull member fixing mechanism does not move to play a supporting role.

[0108] It should be noted that, in some embodiment of the present disclosure, if a distance change on a push-pull end of a push-pull device is detected, due to existence of a moving pulley system, a detected distance change value needs to be divided by two to obtain an actual lift height value of a corresponding fixed point of the spreader.

[0109] FIG. 7 is a schematic structural diagram of a spreader tilting control apparatus according to another embodiment of the present disclosure.

[0110] In some embodiments, referring to FIG. 7, the spreader tilting control apparatus further includes a first flexible safety pull member 30a and a second flexible safety pull member 30b. One end of the first flexible safety pull member 30a is connected to the first flexible pull member 3, and the other end is connected to the second flexible pull member 4. One end of the second flexible safety pull member 30b is connected to the third flexible pull member 5, and the other end is connected to the fourth flexible pull member 6.

[0111] More specifically, one end of the first flexible safety pull member 30a is fixed to a section, of the first flexible pull member 3, obtained after the first flexible pull member 3 goes around a first auxiliary direction changing mechanism 7, and the other end is fixed to a section, of the second flexible pull member 4, obtained after the second flexible pull member 4 goes around a second auxiliary direction changing mechanism 9. One end of the second flexible safety pull member 30b is fixed to a section, of the third flexible pull member 5, obtained after the third flexible pull member 5 goes around a third auxiliary direction changing mechanism 11, and the other end is fixed to a section, of the fourth flexible pull member 6, obtained after the fourth flexible pull member 6 goes around a fourth auxiliary direction changing mechanism 13.

[0112] According to the embodiment of the present disclosure, if a flexible pull member is disengaged from the corresponding push-pull device, a flexible safety pull member connected to

the flexible pull member may hold the flexible pull member and another flexible pull member, so that an accident caused by falling of a spreader may be avoided.

[0113] FIG. 8 is a schematic structural diagram of a part of a spreader tilting control apparatus according to another embodiment of the present disclosure.

5 [0114] In some embodiments, referring to FIG. 4 and FIG. 8, the first push-pull device 101 includes a double-headed push-pull rod 1011. One end of the double-headed push-pull rod 1011 is equipped with a fixed slider 1012a, and the other end is equipped with a fixed slider 1012b. The first push-pull device 101 further includes a sliding seat 1013a and a sliding seat 1013b. The fixed slider 1012a is slidably equipped on the sliding seat 1013a, and the fixed slider 1012b is
10 slidably equipped on the sliding seat 1013b. The first flexible pull member 3 is fixedly connected to the fixed slider 1012a, and the second flexible pull member 4 is fixedly connected to the fixed slider 1012b. The first marker 202 may be fixed to the fixed slider 1012a, or may be fixed to the fixed slider 1012b.

[0115] The second push-pull device 102 includes a push-pull rod 1021. One end of the push-pull
15 rod 1021 is equipped with a fixed slider 1022. The second push-pull device 102 further includes a sliding seat 1023, and the fixed slider 1022 is slidably equipped on the sliding seat 1023. A third flexible pull member 5 is fixedly connected to the fixed slider 1022.

[0116] The third push-pull device 103 includes a push-pull rod 1031. One end of the push-pull
rod 1031 is equipped with a fixed slider 1032. The third push-pull device 103 further includes a
20 sliding seat 1033, and the fixed slider 1032 is slidably equipped on the sliding seat 1033. A fourth flexible pull member 6 is fixedly connected to the fixed slider 1032.

[0117] According to the embodiment of the present disclosure, a sliding track of a fixed slider can be ensured to be stable through cooperation of a sliding seat with the fixed slider. Connecting a flexible pull member to the fixed slider can ensure that connection between the flexible pull
25 member and the push-pull device is more reliable. A first push-pull device is realized as a linear actuator with a double-headed push-pull rod, and both ends of the push-pull rod can be used.

[0118] An embodiment of the present disclosure further provides a crane, which includes the spreader tilting control apparatus provided in the embodiment of the present disclosure.

[0119] FIG. 9 shows a spreader tilting control method according to an embodiment of the present
30 disclosure. The spreader tilting control method may be applied to the spreader tilting control apparatus provided in the embodiments of the present disclosure.

[0120] Referring to FIG. 9, the spreader tilting control method may include Steps 801 to 803.

[0121] In Step 801, a height change value of each lifting end is directly or indirectly measured in real time.

35 [0122] In Step 802, the measured height change value of each lifting end is received.

[0123] In Step 803, an actual tilt angle of a spreader is calculated based on the height change value of each lifting end.

[0124] According to the method described in this embodiment, a height change value of each lifting end may be measured in real time, the measured height change value of each lifting end
5 may be used for display, and real-time tilting status of a spreader is calculated based on the measured height change value of each lifting end.

[0125] The control method provided in this embodiment of the present disclosure may be a feedback control method, which may automatically control the tilt angle of the spreader until a tilt angle, corresponding to an adjustment instruction, of the spreader is reached. The control
10 method may use some existing methods such as closed-loop feedback control, and may be applied in the embodiments of the present disclosure to implement automatic feedback control.

[0126] FIG. 10 shows a spreader tilting control method according to another embodiment of the present disclosure. The spreader tilting control method shown in FIG. 10 is a further extension of the spreader tilting control method shown in FIG. 9. The spreader tilting control method shown
15 in FIG. 10 may include the steps of the spreader tilting control method shown in FIG. 9.

[0127] In Step 901, each lifting mechanism is controlled based on an adjustment instruction to lift and lower, so as to adjust a tilt angle of the spreader.

[0128] In Step 902, the calculated actual tilt angle is received.

[0129] In Step 903, the actual tilt angle is compared with the tilt angle that is corresponding to
20 the adjustment instruction to determine whether the two tilt angles are the same.

[0130] In Step 904, if the two tilt angles are the same, an operation of the lifting mechanism is stopped.

[0131] In Step 905, if the two tilt angles are different, one or more lifting mechanisms are controlled to lift and lower until the two tilt angles are the same.

[0132] In this way, a height of each corner of the spreader may be controlled by means of the lifting mechanisms, then an actual tilt angle is calculated by using a lifting value of each corner, and comparison is performed, so as to control one or more lifting mechanisms by means of feedback control until the tilt angle of the spreader reaches the tilt angle that is corresponding to an adjustment instruction.

[0133] An embodiment of the present disclosure further relates to an electronic device.

[0134] FIG. 11 is a schematic structural diagram of an electronic device according to an embodiment of the present disclosure.

[0135] As shown in FIG. 11, an electronic device 130 includes a processor 1301 and a memory 1302. The processor 1301 is coupled to the memory 1302. The memory 1302 store an instruction
35 executable by the processor 1301. The processor 1301 may perform the spreader tilting control

method provided in the embodiments of the present disclosure based on the instruction stored in the memory 1302.

[0136] The processor 1301 may be a Central Processing Unit (CPU) or a processing unit in another form that has a data handling capacity and/or instruction execution capacity, and may control another component in the electronic device 130 to perform a desired function. Based on the foregoing embodiments, the processor 1301 includes a control module and a processing module. The control module and the processing module each may be a module for implementing a corresponding function in the processor 1301.

[0137] The memory 1302 may include one or more computer program products. The computer program product may include computer-readable storage mediums in various forms, for example, a volatile memory and/or a nonvolatile memory. The volatile memory may include, for example, a random access memory (RAM) and/or a high-speed buffer memory (cache). The nonvolatile memory may include, for example, a read-only memory (ROM), a hard disk, or a flash memory. The computer-readable storage medium may store one or more computer program instructions. The processor 1301 may run the program instructions to implement the method according to the foregoing embodiments of the present disclosure or another desired function. The computer-readable storage medium may further store various content.

[0138] In an example, the electronic device 130 may further include an input apparatus 1303 and an output apparatus 1304. These components may be interconnected to each other by using a bus system and/or a connecting mechanism in another form (not shown in the figure).

[0139] The input apparatus 1303 may include, for example, a keyboard, a mouse, a joystick, and a button.

[0140] The output apparatus 1304 may output various information, including determined motion data and the like. The output apparatus 1304 may include, for example, a display, a communication network and a remote output device connected thereto.

[0141] Certainly, for simplicity, FIG. 11 only shows some of components in the electronic device 130 that are related to the present disclosure, and does not show components such as a bus, an input/output interface, and the like. In addition, according to a specific application situation, the electronic device 130 may further include another proper component.

[0142] An embodiment of the present disclosure further relates to a computer program product, which includes a computer program instruction. When the computer program instruction is run by a processor, the processor implements the spreader tilting control method provided in the embodiments of the present disclosure.

[0143] The computer program product may use one or any combination of more programming languages to write program code for performing operations in the embodiments of the present

disclosure, where the programming languages include an object oriented programming language such as Java and C++, and conventional procedural programming language, such as the “C” language or a similar programming language. The program code may be entirely executed on a user’s computing device, partially on a user’s computing device, executed as an independent software package, partially executed on a user’s computing device and partially executed on a remote computing device, or entirely executed on a remote computing device or a server.

[0144] In addition, an embodiment of the present disclosure further relates to a computer-readable storage medium that stores a computer program instruction. When the computer program instruction is executed by a processor, the processor implements the spreader tilting control method provided in the embodiments of the present disclosure.

[0145] The computer-readable storage medium may use any combination of one or more readable media. The readable medium may be a readable signal medium or readable storage medium. The readable storage medium may include but is, for example, not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or means, or any combination thereof. More specific examples (a non-exhaustive list) of the readable storage medium include an electrical connection having one or more wires, a portable disk, a hard disk, a Random Access Memory (RAM), a Read-Only Memory (ROM), an Erasable Programmable Read-Only Memory (EPROM or a flash memory), an optical fiber, a portable Compact Disc Read-Only Memory (CD-ROM), an optical storage means, a magnetic storage means, or any suitable combination thereof.

[0146] A basic principle of the present disclosure is described with reference to the specific embodiments. However, it should be noted that, the advantages, merits, effects, and the like mentioned in the present disclosure are only examples but not limitations, and it cannot be considered that these advantages, merits, effects, and the like must be provided in the embodiments of the present disclosure. In addition, the specific details disclosed above are for illustrative purpose and for ease of understanding only, but are not for limitations, and are not intended to limit that the present disclosure must be implemented using the specific details.

[0147] The block diagrams of means, apparatuses, devices, and systems related in the present disclosure are only examples for illustrative purposes, and are not intended to require or imply that these means, apparatuses, devices, and systems must be connected, arranged, and configured in the manners shown in the block diagrams. As those skilled in the art will recognize that, these means, apparatuses, devices, and systems can be connected, arranged, and configured in any manner. Words such as “including”, “comprising”, and “having” are open words, which refer to “including but not limited to” and may be used interchangeably with it. The words “or” and “and” used herein refer to the word “and/or”, and may be used interchangeably with it, unless the context

clearly indicates otherwise. The word “such as” used herein refer to the phrase “such as but not limited to”, and may be used interchangeably with it.

[0148] It should also be noted that in the apparatus, device and method of the present disclosure, each component or step may be decomposed and/or recombined. These decomposition and/or recombination should be regarded as an equivalent solution of the present disclosure.

[0149] The above description of the disclosed aspects is provided to enable any person skilled in the art to practice or use the present disclosure. Various modifications to these aspects are very obvious to those skilled in the art, and the general principles defined herein may be applied to other aspects without departing from the scope of the present disclosure. Therefore, the present disclosure is not intended to be limited to these aspects shown herein, but extends to the widest scope that complies with the principles and novel features disclosed in the present disclosure.

[0150] The foregoing descriptions are merely optional embodiments of the present disclosure, but are not intended to limit the present disclosure. Any modification, equivalent replacement, and the like made without departing from the spirit and principle of the present disclosure shall fall within the protection scope of the present disclosure.

What is claimed is:

1. A spreader tilting control apparatus, comprising:

a spreader;

at least one lifting mechanism, wherein each lifting mechanism has a lifting end connected to the spreader, and each lifting mechanism is configured to adjust a tilt angle of the spreader by adjusting a height of the lifting end;

a stroke measurement module, configured to directly or indirectly measure a height change value of the lifting end of each lifting mechanism in real time; and

a processing module, configured to receive the height change value, measured by the stroke measurement module, of the lifting end of each lifting mechanism, and determine an actual tilt angle of the spreader based on the height change value.

2. The spreader tilting control apparatus according to claim 1, further comprising a control module, wherein the control module is configured to:

control, based on an adjustment instruction, each lifting mechanism to adjust the height of the lifting end, so as to adjust the tilt angle of the spreader;

determine whether the actual tilt angle is the same as a tilt angle that is corresponding to the adjustment instruction; and

in response to the actual tilt angle being different from the tilt angle that is corresponding to the adjustment instruction, control each lifting mechanism to adjust the height of the lifting end until the actual tilt angle is the same as the tilt angle that is corresponding to the adjustment instruction.

3. The spreader tilting control apparatus according to claim 1 or 2, wherein the at least one lifting mechanism comprises:

a first lifting mechanism, comprising a first push-pull device and a first flexible pull member, wherein the first flexible pull member is connected to one end of a pull rod of the first push-pull device, and the first push-pull device is configured to pull the first flexible pull member to adjust a height of a lifting end of the first lifting mechanism; and

a second lifting mechanism, comprising the first push-pull device and a second flexible pull member, wherein the second flexible pull member is connected to the other end of the first push-pull device, and the first push-pull device is further configured to pull the second flexible pull member to adjust a height of a lifting end of the second lifting mechanism.

4. The spreader tilting control apparatus according to claim 3, wherein the at least one lifting mechanism further comprises:

a third lifting mechanism, comprising a second push-pull device and a third flexible pull member, wherein the second push-pull device is configured to pull the third flexible pull member to adjust a

height of a lifting end of the third lifting mechanism; and

a fourth lifting mechanism, comprising a third push-pull device and a fourth flexible pull member, wherein the third push-pull device is configured to pull the fourth flexible pull member to adjust a height of a lifting end of the fourth lifting mechanism.

5 5. The spreader tilting control apparatus according to claim 4, wherein the first lifting mechanism further comprises a first direction changing mechanism, the first direction changing mechanism is located between the first push-pull device and the spreader, the first flexible pull member is wound on the first direction changing mechanism, and the first direction changing mechanism is configured to change a force application direction of the first flexible pull member;

10 the second lifting mechanism further comprises a second direction changing mechanism, the second direction changing mechanism is located between the first push-pull device and the spreader, the second flexible pull member is wound on the second direction changing mechanism, and the second direction changing mechanism is configured to change a force application direction of the second flexible pull member;

15 the third lifting mechanism further comprises a third direction changing mechanism, the third direction changing mechanism is located between the second push-pull device and the spreader, the third flexible pull member is wound on the third direction changing mechanism, and the third direction changing mechanism is configured to change a force application direction of the third flexible pull member; and

20 the fourth lifting mechanism further comprises a fourth direction changing mechanism, the fourth direction changing mechanism is located between the third push-pull device and the spreader, the fourth flexible pull member is wound on the fourth direction changing mechanism, and the fourth direction changing mechanism is configured to change a force application direction of the fourth flexible pull member.

25 6. The spreader tilting control apparatus according to claim 4 or 5, wherein the lifting end of the first lifting mechanism, the lifting end of the second lifting mechanism, the lifting end of the third lifting mechanism, and the lifting end of the fourth lifting mechanism are arranged to define a quadrilateral, and the lifting end of the first lifting mechanism and the lifting end of the second lifting mechanism are respectively located at two opposite vertices of the quadrilateral.

30 7. The spreader tilting control apparatus according to claim 5, wherein a portion, located between the first direction changing mechanism and the first push-pull device, of the first flexible pull member is collinear with a portion, located between the second direction changing mechanism and the first push-pull device, of the second flexible pull member.

35 8. The spreader tilting control apparatus according to claim 5, wherein the first lifting mechanism further comprises a first auxiliary direction changing mechanism, the first auxiliary direction changing

mechanism is located between the first direction changing mechanism and the first push-pull device, the first flexible pull member is wound on the first auxiliary direction changing mechanism, and the first auxiliary direction changing mechanism is configured to change the force application direction of the first flexible pull member;

5 the second lifting mechanism further comprises a second auxiliary direction changing mechanism, the second auxiliary direction changing mechanism is located between the second direction changing mechanism and the first push-pull device, the second flexible pull member is wound on the second auxiliary direction changing mechanism, and the second auxiliary direction changing mechanism is configured to change the force application direction of the second flexible pull member;

10 the third lifting mechanism further comprises a third auxiliary direction changing mechanism, the third auxiliary direction changing mechanism is located between the third direction changing mechanism and the second push-pull device, the third flexible pull member is wound on the third auxiliary direction changing mechanism, and the third auxiliary direction changing mechanism is configured to change the force application direction of the third flexible pull member; and

15 the fourth lifting mechanism further comprises a fourth auxiliary direction changing mechanism, the fourth auxiliary direction changing mechanism is located between the fourth direction changing mechanism and the third push-pull device, the fourth flexible pull member is wound on the fourth auxiliary direction changing mechanism, and the fourth auxiliary direction changing mechanism is configured to change the force application direction of the fourth flexible pull member.

20 9. The spreader tilting control apparatus according to claim 8, wherein a portion, located between the first auxiliary direction changing mechanism and the first push-pull device, of the first flexible pull member is collinear with a portion, located between the second auxiliary direction changing mechanism and the first push-pull device, of the second flexible pull member.

25 10. The spreader tilting control apparatus according to any one of claims 4 to 9, wherein one end of the first flexible pull member is connected to the first push-pull device, the other end is connected to the spreader, and the lifting end of the first lifting mechanism is the end, connected to the spreader, of the first flexible pull member;

30 one end of the second flexible pull member is connected to the first push-pull device, the other end is connected to the spreader, and the lifting end of the second lifting mechanism is the end, connected to the spreader, of the second flexible pull member;

one end of the third flexible pull member is connected to the second push-pull device, the other end is connected to the spreader, and the lifting end of the third lifting mechanism is the end, connected to the spreader, of the third flexible pull member; and

35 one end of the fourth flexible pull member is connected to the third push-pull device, the other end is connected to the spreader, and the lifting end of the fourth lifting mechanism is the end, connected to

the spreader, of the fourth flexible pull member.

11. The spreader tilting control apparatus according to any one of claims 4 to 9, wherein the spreader tilting control apparatus further comprises a pull member fixing mechanism, wherein

5 the first lifting mechanism further comprises a first hoisting pulley, the first hoisting pulley is fixed to the spreader, one end of the first flexible pull member is connected to the pull member fixing mechanism, the other end goes around the first hoisting pulley and is connected to the first push-pull device, and the lifting end of the first lifting mechanism is a portion, connected to the spreader, of the first hoisting pulley;

10 the second lifting mechanism further comprises a second hoisting pulley, the second hoisting pulley is fixed to the spreader, one end of the second flexible pull member is connected to the pull member fixing mechanism, the other end goes around the second hoisting pulley and is connected to the first push-pull device, and the lifting end of the second lifting mechanism is a portion, connected to the spreader, of the second hoisting pulley;

15 the third lifting mechanism further comprises a third hoisting pulley, the third hoisting pulley is fixed to the spreader, one end of the third flexible pull member is connected to the pull member fixing mechanism, the other end goes around the third hoisting pulley and is connected to the second push-pull device, and the lifting end of the third lifting mechanism is a portion, connected to the spreader, of the third hoisting pulley; and

20 the fourth lifting mechanism further comprises a fourth hoisting pulley, the fourth hoisting pulley is fixed to the spreader, one end of the fourth flexible pull member is connected to the pull member fixing mechanism, the other end goes around the fourth hoisting pulley and is connected to the third push-pull device, and the lifting end of the fourth lifting mechanism is a portion, connected to the spreader, of the fourth hoisting pulley.

25 12. The spreader tilting control apparatus according to any one of claims 4 to 11, wherein the spreader tilting control apparatus further comprises a first flexible safety pull member and a second flexible safety pull member, one end of the first flexible safety pull member is connected to the first flexible pull member, the other end of the first flexible safety pull member is connected to the second flexible pull member, one end of the second flexible safety pull member is connected to the third flexible pull member, and the other end of the second flexible safety pull member is connected to the fourth
30 flexible pull member.

13. The spreader tilting control apparatus according to any one of claims 4 to 12, wherein the stroke measurement module comprises:

35 a first set of laser ranging system, comprising a first laser range finder and a first marker, wherein the first laser range finder is fixed to the first push-pull device, the first marker is fixed to one of a push-pull end of the first push-pull device, the first flexible pull member, and the second flexible pull member,

and a ranging laser of the first laser range finder is irradiated on the first marker to measure a position change value of the first marker, so as to measure a height change value of the lifting end of each of the first lifting mechanism and the second lifting mechanism;

a second set of laser ranging system, comprising a second laser range finder and a second marker, wherein the second laser range finder is fixed to the second push-pull device, the second marker is fixed to a push-pull end of the second push-pull device or fixed to the third flexible pull member, and a ranging laser of the second laser range finder is irradiated on the second marker to measure a position change value of the second marker, so as to measure a height change value of the lifting end of the third lifting mechanism; and

a third set of laser ranging system, comprising a third laser range finder and a third marker, wherein the third laser range finder is fixed to the third push-pull device, the third marker is fixed to a push-pull end of the third push-pull device or fixed to the fourth flexible pull member, and a ranging laser of the third laser range finder is irradiated on the third marker to measure a position change value of the third marker, so as to measure a height change value of the lifting end of the fourth lifting mechanism.

14. The spreader tilting control apparatus according to claim 13, wherein the first push-pull device comprises a double-headed push-pull rod, the double-headed push-pull rod is connected to the first flexible pull member and the second flexible pull member respectively through a pair of fixed sliders respectively located at two opposite ends of the double-headed push-pull rod, the pair of fixed sliders are respectively slidably mounted on a pair of sliding seats, and the first marker is fixed to one of the pair of the fixed sliders; and

the second push-pull device is connected to the third flexible pull member through a fixed slider located at an end of a push-pull rod of the second push-pull device, and the third push-pull device is connected to the fourth flexible pull member through a fixed slider located at an end of a push-pull rod of the third push-pull device; each one of the fixed slider located at the end of the push-pull rod of the second push-pull device and the fixed slider located at the end of the push-pull rod of the third push-pull device is slidably mounted on a corresponding sliding seat; the second marker is fixed to the fixed slider located at the end of the push-pull rod of the second push-pull device, and the third marker is fixed to the fixed slider located at the end of the push-pull rod of the third push-pull device.

15. A crane, wherein the crane comprises the spreader tilting control apparatus according to any one of claims 1 to 14.