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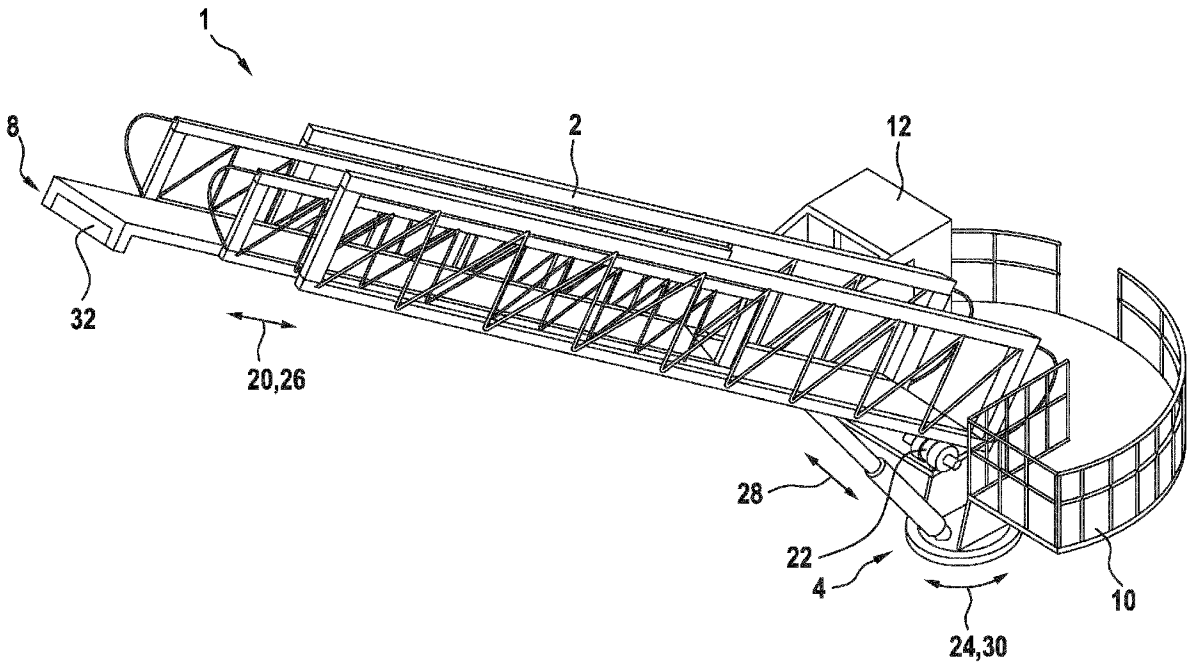
(54) MOTION COMPENSATING GANGWAY AND METHOD FOR CONTROLLING THE SAME

(57) A motion compensating gangway (1) comprises a proximal end (4), a distal end (8), a walkway (2) between these, an actuator (26, 28, 30) for moving the distal end (8) relative to the proximal end (4) upon command from a control unit, at least one sensor (32) for determining a condition of contact between the distal end (8) and a separate structure, and a contact mode wherein the control unit controls the distal end (8) position relative to the proximal end (4), based on at least a signal from a motion reference unit and a signal from the sensor.

Fig. 1



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Description

Technical Field

[0001] The present invention relates to a motion compensating gangway, in particular a motion compensating gangway having a walkway.

Background Art

[0002] A motion compensating gangway (hereinafter "gangway") is known for transferring people and/or loads from a floating vessel to an offshore structure such as an oil platform or wind turbine. The gangway has a proximal end provided on a vessel (for example fixed to the vessel's deck) and a distal end to be positioned on the offshore structure. Since the vessel is influenced by wave movement its position and orientation tends to change over time, relative to the offshore structure which can be considered fixed relative to the earth. To allow passage between the vessel and the offshore structure it is known to provide the gangway with a motion compensation system for controlling its movement, especially movement at the distal end.

[0003] Typically, in preparation for landing the gangway on the offshore structure, an operator will move the gangway's distal end overboard and switch on a motion compensation system. In this way the distal end can be brought under active motion compensation (AMC) into a desired position relative to the landing portion. AMC is based on measurements from a motion reference unit (MRU) detecting changes in the position and orientation of the vessel. So the distal end remains steady with respect to the offshore structure, while the proximal end of the gangway can move with the vessel. The operator is then able to make the distal end contact the landing portion of the offshore structure. With a stable engagement between the distal end and the landing portion, personnel can cross the gangway one by one. When all personnel have crossed the bridge the operator will regain manual control to retract the gangway, switch off motion compensation, and then place the gangway in the stowed position on the vessel.

[0004] However the above-described system is prone to some inaccuracies in the positioning of the distal end due to e.g. errors in the MRU measurements. It is not easy to achieve a stable engagement between the distal end and the landing portion. Additional steps must be taken to minimize undesired movement between these. For example it is known to change the control mode of the gangway from AMC to a passive mode. Under the passive mode the gangway applies from its distal end a load to the landing portion (e.g. by applying constant loads at the gangway's actuators). The operator can initiate this mode after pushing the gangway against the landing portion. If for any reason (e.g. unexpected weather events) the distal end loses contact with the landing portion, then the passively applied loads could bring the gangway into a state of imbalance, for example wherein said loads are not counterbalanced properly with the weight of the gangway or other forces, and the gangway might move unexpectedly. To account for this it is known to apply additional measures to achieve an appropriate safety level to this type of gangway, such as limiting the maximum wave height at which the gangway is allowed to operate. It is also known to provide dynamic gripping mechanisms at the distal end which engage with the landing portion. These measures reduce the operability of the gangway and complicate the design.

[0005] A motion compensating gangway having the features of the preamble of claim 1 is known from EP3022112A1.

Summary of the Invention

[0006] It is an object of the invention to provide a way to reduce undesired movement of the gangway, in particular between the gangway and an offshore structure. It is a further object to provide a simple operation and construction.

[0007] The objects are achieved by the respective subject-matter of claims 1 and 6. Advantageous further developments are subject-matter of the dependent claims.

[0008] A motion compensating gangway according to the invention comprises: a proximal end, a distal end, a walkway between these, a control unit, and one or more actuators for moving the distal end relative to the proximal end upon command from the control unit, further comprising: at least one sensor for determining a condition of contact between the distal end and a separate structure, and a contact mode wherein under the contact mode the control unit is configured to control the distal end position relative to the proximal end, based on at least a signal from a motion reference unit and a signal from the sensor. Therefore the motions at the proximal end (motions of the vessel) are at least partially compensated at the distal end. By providing the sensor signal the distal end can be kept steady against the offshore structure more steadily and/ or with greater accuracy.

[0009] Preferably the control unit may have a control algorithm for keeping, under the contact mode, the distal end (tip) fixed against the offshore structure, wherein a position or force in one or more degrees of freedom is sensed at the distal end by the sensor.

[0010] It may be provided that in the contact mode the control unit controls (or is configured to control) the condition of contact. So during said compensation the control unit may receive a signal from the sensor which may be used when determining how to drive the one or more actuators in a way that controls the contact condition. Therefore by providing and controlling the sensor signal, the distal end can be kept steady against the offshore structure more reliably and/ or with greater accuracy.

[0011] It may be provided that the contact condition is controlled, under the contact mode, by means of a negative feedback loop. Preferably the contact condition may be kept within a target range, kept above or below one or more predetermined thresholds, or kept at or close to a predetermined value or predetermined values.

[0012] A contact condition may include a vector or scalar quantity relating to any or all of a force (e.g. a normal force or frictional force), a pressure, a moment, and a location of contact. Furthermore the condition may include a change or rate of change in any or all of these.

[0013] A contact state may be understood to mean being in contact with or being connected (e.g. by a region or point at the distal end) to a landing portion being a region or point on a structure, such as an offshore structure.

[0014] The signal from a motion reference unit may comprise either or both of information related to the motion at the distal end with respect to a fixed framework, and information related to the motion of a vessel on which the proximal end is to be fixed.

[0015] A fixed framework may be a global coordinate system.

[0016] The offshore structure may be fixed relative to the fixed framework.

[0017] The motion reference unit may preferably measure motion in degrees of freedom, such as in six degrees of freedom.

[0018] It may be provided that the at least one actuator is provided as a plurality of actuators (preferably two or three actuators). Preferably each actuator may be able to move the distal end relative to the proximal end in a respective degree of freedom. So a plurality of actuators can be controlled more easily (with less mutual interaction) than, e.g. a hexapod platform arrangement which requires resonance and vibrational management. Because any transfer deck can remain stationary to the vessel, the flow of personnel crossing the walkway is not reduced.

[0019] It may be provided that the walkway is telescopically actuatable by a telescopic actuator.

[0020] It may be provided that the control unit is configured to control the distal end position relative to the proximal end so that any movements of the proximal end with respect to a fixed framework are not transferred or transferred only partially to the distal end. So the signal from the MRU is used to effect motion compensation.

[0021] It may be provided that the at least one sensor is provided at or on the distal end.

[0022] It may be provided that the contact condition comprises a position. The position may include a relative position (or change therein) between a point on the distal end and a point on the landing portion at a predetermined timing upon or during the contact state.

[0023] It may be provided that the contact condition comprises one or both of a force and a pressure. For example the distal end may include a compliant region, and deformation of the compliant region is dependent on the contact force, the deformation in one or more directions being detectable by the sensor. Sensing a force at the distal end is generally advantageous when it comes to controlling a position because slipping or loss of contact is often preceded by a change in contact force.

[0024] It may be provided that the actuators include any or all of a telescopic actuator, a luffing actuator, and a slewing actuator. When the motion is actively compensated by a hydraulic system, preferably the hydraulic system includes slewing gears, a luffing cylinder, and a winch controlling the telescopic motion.

[0025] It may be provided that the gangway is configured, under the contact mode, to maintain a target distal end position with respect to a separate structure while applying a target force at the distal end. So now a constant force can be applied more steadily and accurately at the contact point than if, for example, loads (such as gas springs) were applied at the actuator(s). The contact force may be a scalar or vector quantity.

[0026] A deployment mode may be provided wherein the control unit is configured to control the distal end position relative to the proximal end, based on at least the signal from the motion reference unit, and/or any manual commands from an operator. So the gangway can change between at least two modes which furthermore use common elements with minor modification. Preferably it may be provided that in the deployment mode the contact condition is not controlled. So in the deployment mode the distal end position is controlled (e.g. kept stationary or moved according to a command from an operator) with respect to the offshore structure which is considered to be stationary relative to the fixed world. The control unit can generally drive the actuators based on the signal from the MRU. For example the MRU signal may comprise information about a vector or vectors representing the position and orientation of the vessel (or change in these), and the control unit may drive the one or more actuators so that a compensating or partially compensating movement of the distal end with respect to the vessel is achieved. Commands from an operator can smoothly move the distal end relative to the vessel. In the contact mode the sensor signal is used to further enhance the motion compensation at the distal end. In the contact mode any operator need not manually command the gangway movements. In this way the distal end can be kept essentially stationary relative to the fixed world (fixed framework).

[0027] It may be provided that the control unit is configured to change between the deployment mode and the contact mode based on at least the signal from the at least one sensor. For example the change may be triggered when the signal passes a predetermined threshold or thresholds optionally comprising hysteresis.

[0028] The control unit may preferably include a distal end setpoint determining section for determining under at least the contact mode, and based on at least the signal from the motion reference unit, a distal end setpoint; and further preferably an actuator setpoint determining section for determining, under the contact mode, for the actuator (or for each actuator if more than one actuator are provided), and based on at least the distal end setpoint and the signal from the sensor, a respective actuator setpoint. So now under the contact mode the distal end setpoint need not be determined based on the sensor signal - rather the actuator setpoint is determined based on the sensor signal. The distal end setpoint can be used in the control of another control mode, such as a deployment mode, with little or no modification. The control unit is simplified.

[0029] It may be provided that a distal end setpoint may include information related to the target position of the distal end relative to the proximal end.

[0030] It may be provided that an actuator setpoint may include information related to the target actuation amount of the actuator.

[0031] It may be provided that the actuator setpoint determining section is configured to determine, for each at least one actuator, an unadjusted actuator setpoint based on at least the distal end setpoint, and is configured to determine an adjustment value for adjusting the unadjusted actuator setpoint, based on the signal from the at least one sensor. In other words, based on feedback from the sensor(s), the actuator setpoint is adjusted.

[0032] Preferably the control unit may comprise a system controller, and an actuator controller for determining an actuator command such as a control voltage, based on an actuator setpoint received from the system controller and a signal from an inner feedback loop.

[0033] A method is provided for controlling a motion compensating gangway having a proximal end, a distal end, a walkway between these, and one or more actuators for moving the distal end relative to the proximal end, the method comprising the steps of: determining a movement of the proximal end which is a movement with respect to a fixed framework, determining a condition of contact between the distal end and a separate structure, judging whether to operate the gangway in a contact mode based on the determined condition of contact, and when operating the gangway in the contact mode, driving the one or more actuators based on at least the determined movement of the proximal end and the determined condition of contact.

[0034] The method may preferably comprise, when operating the gangway in the contact mode, the steps of: determining a distal end setpoint based on at least the determined movement of the proximal end; determining, for the actuator (or for each actuator, if several actuators are provided), and based on at least the distal end setpoint and the determined condition of contact, a respective actuator setpoint; and driving the actuator (or each actuator if many actuators are provided) based on the respective actuator setpoint.

[0035] The method may preferably comprise, when operating the gangway in the contact mode, the steps of: determining, for each actuator, and based on at least the distal end setpoint, a respective unadjusted actuator setpoint; determining, for each actuator, an actuator setpoint adjustment amount based on the contact condition; and adjusting, for each actuator, the unadjusted actuator setpoint based on the adjustment amount, to determine the respective actuator setpoint.

[0036] It may be provided, in the gangway and/or in the method, that the adjustment value is based additionally on a setpoint of at least one other actuator and/or a determined actuation position of at least one other actuator. So the adjustment values are determined with interdependence and a more steady distal end is effected.

[0037] It may be provided that, when operating the gangway in the contact mode, the one or more actuators are driven so that a target distal end position with respect to the separate structure (a fixed framework) is maintained and simultaneously a target force at the distal end is applied.

Short Description of the Figures

[0038] Preferred embodiments are described in more detail in the following with the help of the appended figures, wherein:

Fig. 1 shows a motion compensating gangway according to an embodiment of the invention, and

Fig. 2 shows a block diagram representing the control elements for the gangway of the embodiment.

Detailed Description of Embodiment

[0039] Fig. 1 shows a motion compensating gangway 1 according to an embodiment of the invention.

[0040] The gangway 1 includes a walkway 2 which is telescopically actuatable in a longitudinal direction. A proximal end 4 is directly or indirectly fixed to a vessel (not shown), e.g. to be stationary relative to the deck of a ship. A distal end 8 is at a free end of the walkway 2 and is configured to contact an offshore structure (not shown in Fig. 1, shown as 68 in Fig. 2). The gangway 1 includes a transfer deck 10 where personnel can wait while the gangway 1 is being deployed, and a control station 12 preferably comprising any or all of control cabinets, operator controls, and a cabin.

[0041] The gangway 1 is provided with joints 20, 22, 24 which allow the distal end 8 to be moved relative to the proximal end 4. A telescopic joint 20 allows the distance between the proximal end 4 and the distal end 8 to change by extending / contracting the walkway 2. A luffing joint 22 having a luffing axis allows the inclination of the distal end 8 relative to the proximal end 4 to change by pivoting the walkway 2 about an essentially horizontal vessel axis. A slewing joint 24 having a slewing axis perpendicular to the luffing axis allows the gangway 1 to rotate about an essentially vertical vessel axis.

[0042] Each of the telescopic 20, luffing 22, and slewing 24 joint is drivable by respective actuators 26, 28, 30. Specifically the telescopic joint 20 is drivable by at least one telescopic actuator 26 as a winch. The winch may be drivable e.g. hydro-mechanically, optionally via a second transmission. The luffing joint 22 is drivable by one or more luffing actuators; in the present embodiment one luffing actuator 28 is provided as a single hydraulic cylinder. The slewing joint 24 is drivable by a hydromechanical slewing actuator 30. It can be appreciated that alternative actuators may be selected to drive the respective joints 20, 22, 24, in view of sizing considerations and operating conditions. For example the telescopic joint 20 may be driven by one or more hydraulic cylinders. The actuators 26, 28, 30 and, where applicable, the joints 20, 22, 24 are indicated in Fig. 1 by double-headed arrows representing their respective directions of actuation.

[0043] When a contact state is determined to exist, the gangway 1 operates in a contact mode. The distal end 8 is brought into the contact state by the command of the operator at the control station 12. The gangway 1 is provided with at least one distal end sensor 32 (hereinafter "sensor 32") for measuring a contact condition between the distal end 8 and the offshore structure. Preferably the sensor 32 is provided on or at the distal end 8, which is the case in the present embodiment. The contact condition may be a (change in) position of the distal end 8 relative to the landing portion, and/or a force at the distal end 8, in one or more degrees of freedom. To achieve this the sensor 32 may comprise any or all of a position sensor, a proximity sensor, a velocity sensor, and a force meter. The distal end may comprise a resilient member (bumper) and a force is determined through a sensor measuring any resilient deformation.

[0044] The functioning of the control unit 40 under the contact state is described in detail in the following with the help of Fig. 2 which shows a block diagram representing control elements for the gangway 1 being in contact with the offshore structure 68.

[0045] The gangway 1 has a control unit 40 which can receive a signal from a motion reference unit 42 (MRU) provided on the vessel. Optionally the gangway 1 may comprise the MRU 42. The MRU 42 may comprise accelerometers and optionally an image recognition device. The MRU 42 measures vessel motion in up to six degrees of freedom. Information relating to the relative positions and orientations of the MRU 42 and gangway 1 are stored in one or both of the MRU 42 and control unit 40.

[0046] The control unit 40 includes a system controller 48 which transforms the vessel motion based on information relating to the relative positions and orientations of the MRU 42 and gangway 1, to a target position and/or motion of the distal end 8 with respect to the vessel, so that the vessel movement is compensated. In doing so a setpoint for the distal end 8 is determined, preferably by a distal end setpoint determining section provided in the system controller 48. The setpoint of the distal end 8 includes information regarding any or all of the target position, velocity and acceleration of the distal end 8.

[0047] The system controller 48 also receives a signal 52 from the sensor 32, such as a voltage signal, representing the contact condition. Information relating to a target sensor value may be stored in a memory, for example in the system controller 48.

[0048] The system controller 48 can determine a respective actuator setpoint 54 for each actuator, based on at least the distal end setpoint, the sensor signal 52, and the target sensor value. An actuator setpoint 54 includes information regarding any or all of the desired position, velocity and acceleration of the actuator's movement for driving its corresponding joint. The system controller 48 may include means, such as an actuator setpoint determining section preferably including a control algorithm. So the system controller can perform for example an axis transformation from vessel motions (from the MRU signal) to the distal end setpoint (with respect to the vessel).

[0049] The system controller 48 determines suitable actuator setpoints 54 so that the sensor signal 52 approaches or reaches the target sensor value. So a negative feedback loop is provided as an outer feedback loop 56. For example the sensor signal 52 is received by the system controller 48 and compared to the target sensor value, and a deviation from a desired position and/or force is determined. The actuator setpoints 54 are determined based on the deviation. So the vessel motion is compensated sufficiently so that the sensor signal 52 falls within a predetermined sensor value which can include a range of predetermined sensor values and/or predetermined sensor value thresholds. As an exemplary way of using the sensor signal 52: the system controller 48 in one step may determine unadjusted actuator setpoints based on the distal end setpoint, for example using the axis transformation from vessel motions described above. In a later step the system controller 48 may determine adjusted actuator setpoints by adjusting the unadjusted actuator setpoints through adjustment amounts based on the deviation of the sensor signal 52 from the target sensor value. The system controller 48 may include means, such as a second control algorithm. Thus the adjusted actuator setpoints ("actuator setpoints 54") are determined.

[0050] A signal representing the actuator setpoints 54 is sent from the system controller 48 and received by an actuator controller 58 which determines actuator commands for driving the actuators 26, 28, 30. An actuator command 60 could be, for example, a control voltage for opening a proportional solenoid valve. So the actuator controller 58 determines the actuator commands 60 for achieving the actuator setpoints 54. To do this each actuator may be provided with one or more actuator sensors for providing the actuator controller 58 with a signal 62 related to position information on which the actuator commands 60 are based. The respective sensors may be provided on each actuator or on the gangway 1 structure to determine the gangway's movement in the telescopic, luffing and slewing directions (i.e. in the degrees of freedom of the respective actuators). So an inner feedback loop 64 provides closed-loop and negative feedback control to the actuators 26, 28, 30. The inner feedback loop 64 may include a respective feedback loop for each actuator.

[0051] Communicating elements, such as the MRU 42, system controller 48, actuator controller 58, actuator sensors and distal end sensor 32, may send and receive the respective signals at predetermined intervals.

[0052] Therefore, in the contact state the control unit 40 can drive the actuators 26, 28, 30 based on the signal from the MRU 42 and simultaneously based on the signal from the sensor 32. For example the actuators 26, 28, 30 can be driven in response to the MRU signal 44 and at the same time so that the signal at the sensor 32 remains within a target range. The movements of the actuators 26, 28, 30 effect corresponding movements of the mechanical structure 66 (e.g. joints) of the gangway 1 which movements can influence the condition of contact with the offshore structure 68, the condition being detected by the sensor 32.

[0053] The embodiment has the following advantages. The distal end 8 can be kept fixed against the offshore structure 68 more steadily and/ or with greater accuracy than if a passive mode were adopted, or if an AMC were maintained in which the actuators 26, 28, 30 were driven based on the MRU signal 44 and without the sensor signal 52. This is because, due to any of: measurement errors in the MRU, control errors in the control of the actuators 26, 28, 30, and deformation of mechanical structures, undesired deviations can be introduced to the position of the distal end 8, such that additional measures must be taken to avoid slipping or loss of contact. But in the embodiment the outer feedback loop 56 allows the actuator setpoints 54 to be adjusted so that the deviations are reduced or removed. The gangway 1 can compensate for not just vessel movements but also for the undesired deviations. On the other hand, determining the actuator setpoints 54 based on the inner feedback loop 64 without the outer feedback loop 56 would not keep the distal end optimally steady against the offshore structure 68. The operator need not manually operate the gangway 1 in the contact state; the gangway 1 will remain in contact by itself.

[0054] For example in order to compensate for any error, the sensor 32 at the distal end 8 measures a force or position/distance and is used for the outer feedback loop 56, which compensates for any remaining undesired deviations of the distal end position/force. This means that the force or position at the distal end 8 can be the setpoint of a control algorithm, and the sensor signal 52 is used to determine if this setpoint is met.

[0055] The advantages of the embodiment are further illustrated in the following by contrasting with a comparative example. In the comparative example, when the distal end is not yet in contact with the offshore structure the gangway is controlled by active motion control, but when contact is made with the offshore structure the gangway enters a passive mode wherein the joints are connected to urging means such as pressurized gas vessels; an essentially constant load is applied to a joint or joints, e.g. similar to spring loading the joints, or an essentially constant pressure may drive the actuator. The passive mode does not actively compensate for wave movements, and there is no outer feedback loop. So in this comparative example there is a changeover from active control when the distal end is not in contact (e.g. deployment), to passive control when the distal end is in contact. For example the comparative example switches from (actuator) position control to constant pressure on each actuator. If for any reason the distal end loses contact with the offshore structure, the comparative gangway is still being controlled passively and slipping is not only more likely but an unpredictable state could be created if slipping were to occur.

[0056] On the other hand in the invention the actuators are driven based on the MRU signal 44 and additionally on the sensor signal 52. Now, for example the frictional or contact force(s) between the distal end 8 and the offshore structure 68 can be kept within a predetermined range, for example a load acting downwards equivalent to the gravitational force of several hundred kilograms may be applied at the distal end 8. This achieves a more reliable and stable contact than if merely the loads at each actuator were set through a passive mode. The gangway 1 has a dependable control level without the need for additional control elements. If the sensor 32 includes a force sensor and optionally also a position sensor it is possible to maintain a steady contact location on the offshore structure 68 while also maintaining a predetermined load at that contact location, with even further steadiness. Loss of contact is now even less likely. In the unlikely event of undesired loss of contact, the movement of the gangway 1 can still be compensated temporarily with the MRU signal 44 and without the sensor signal 52, i.e. for the brief period until contact is regained, and movement is not unpredictable.

[0057] In the invention the distal end 8 is controlled based on both the MRU signal 44 and the sensor signal 52. Since the MRU signal 44 has information concerning vessel movement in many degrees of freedom, advantages of the invention are still achieved if the sensor 32 has information concerning the contact condition in a reduced number of degrees of freedom.

[0058] The invention need not include a dynamic grabbing means, such as an actuatable gripper at the contact interface, or a form-locking fit, such as provided by a protrusion engaging into a slot.

[0059] When the distal end 8 is not in contact with the offshore structure 68 (e.g. in a deployment state where the distal end 8 moves towards or away from the offshore structure 68) the control unit 40 of the gangway of the example may enter a deployment mode in which the contact mode is modified at least by not providing the outer control loop and by receiving a command signal from a human operator. In this case there is no need to provide a separate and independent control structure for the contact and deployment modes. In the deployment mode the distal end setpoint may be based on the MRU signal 44, the command signal from the operator and not on the signal from the sensor 32. However the sensor signal 52 may still be used to determine when contact is made, and so the changing between the contact mode and the deployment mode can be based on the sensor value (e.g. by determining whether the sensor value falls above or below one or more predetermined thresholds). Both the contact mode and the deployment mode comprise active motion compensation, in particular in the slewing direction, luffing direction and telescoping direction to keep the distal end 8 at least partially steady.

[0060] The actuator controller 58 has an input signal being actuator setpoints 54 (e.g. actuation positions), and an output signal being actuator commands 60, wherein said output signal is regulated by means of a self-contained inner feedback loop 64. The operation of the actuator controller 58 may be the same in the contact mode as in the deployment mode. So a modular construction is facilitated. Preferably the actuator commands 60 may be determined with direct dependence on the MRU signal 44.

[0061] The gangway 1 is operable over large wave heights. The maximum wave height while still allowing operation is not limited by the compensation performance, but can be set to e.g. 3 metres, in view of the location of the gangway 1 on the vessel, and/or whether people can cross the walkway 2 comfortably.

[0062] Advantages can be achieved even if the gangway 1 is attached to a vessel that lacks dynamic positioning means. It is not necessary to push the vessel against the offshore structure 68.

[0063] In the embodiment the actuators are provided as telescopic, luffing, and slewing actuators 26, 28, 30. The actuators can be easily hydraulically driven.

[0064] The gangway according to the invention can be easily adapted to function as a crane, such as a luffing crane.

[0065] The following modifications may be independently made without deviating from the scope of the invention.

[0066] Some motion compensation is possible even if the gangway actuatably moves in only one or two degrees of freedom.

[0067] The gangway may be provided on a pedestal. The pedestal may be interposed between the proximal end 4 and the vessel. By raising the height of the proximal end 4 in this way the height of the distal end 8 can be more closely matched to the height of landing portions on a variety of offshore structures. So the inclination of the walkway 2 can be kept below a suitable limit. The height of the proximal end 4 from the vessel may be adjustable. Further preferably the pedestal itself may have a fixed height; this simplifies provisions for allowing personnel to access the gangway via the pedestal, e.g. via an elevator in a fixed-height elevator shaft which is provided at or in the pedestal.

[0068] The gangway may have a passive mode such as the passive mode described above for the comparative example, in addition to the embodiment's deployment mode and contact mode. This passive mode can be used as a backup control mode to replace the contact mode when an anomaly is detected.

[0069] The control unit 40 may comprise a fade-in (soft transition) functionality, thus effecting a gradual change between one control modes.

[0070] The gangway may be provided with a tilting joint and accompanying actuator or actuators for changing an orientation of the walkway 2 about a rolling axis that is perpendicular to both the luffing and slewing axes. The tilting actuator may be passively or actively driven in the same way as the active control of the telescopic, luffing and slewing actuators 26, 28, 30 described above.

[0071] The gangway can have arrangements other than a joint and an actuator for each of a telescopic, luffing and slewing direction, such as an arrangement having several telescopic joints and/or a hexapod platform.

[0072] The actuators may be driven by means/devices other than hydromechanical ones. For example the actuators may be driven at least partially electromechanically.

[0073] A passive load such as a gas spring may be provided respectively at one or more of the actuators that support gravitational loads. So the nominal load capacity of these actuators can be reduced.

[0074] The system controller 48 and actuator controller 58 may be provided in a common control unit 40 or as separate elements. The system controller 48 and actuator controller 58 may be located at the control station 12. One or both of these may be located away from the gangway structure. The gangway need not include the actuator controller 58.

[0075] A signal may comprise a plurality of signals. The sensor signal 52 comprise information related to a vector quantity. However improved compensation is possible even if the sensor signal represents a scalar quantity.

[0076] The motion compensated gangway of the invention keeps the distal end in contact with the landing location, at the same point of contact. During compensation the position of the distal end with respect to the fixed world is controlled based on at least the Motion Reference Unit (MRU) signals.

[0077] For further controlling the gangway as closed loop during contact, a sensor may provide the feedback to close the outer loop. Based on the feedback of the distal end sensor, the actuator setpoints are adjusted.

Reference Signs

[0078]

1	motion compensating gangway
2	walkway
4	proximal end
8	distal end
10	transfer deck
12	control station
20	telescopic joint

22 luffing joint
24 slewing joint
26 telescopic actuator
28 luffing actuator
30 slewing actuator
32 sensor
40 control unit
42 motion reference unit (MRU)
44 signal from motion reference unit
48 system controller
52 sensor signal
54 actuator setpoint
56 outer feedback loop
58 actuator controller
60 actuator command
62 actuator sensor signal
64 inner feedback loop
66 mechanical structure of gangway
68 offshore structure

Claims

1. A motion compensating gangway comprising:

   a proximal end (4), a distal end (8), a walkway (2) between these, a control unit (40), and one or more actuators (26, 28, 30) for moving the distal end (8) relative to the proximal end (4) upon command from the control unit (40), **characterized by comprising**
   at least one sensor (32) for determining a condition of contact between the distal end (8) and a separate structure (68), and
   a contact mode, wherein under the contact mode the control unit (40) is configured to control the distal end (8) position relative to the proximal end (4), based on at least a signal (44) from a motion reference unit (42) and a signal (52) from the sensor (32).

2. Motion compensating gangway according to claim 1, wherein the actuators include any or all of a telescopic actuator (26), a luffing actuator (28), and a slewing actuator (30).

3. Motion compensating gangway according to either one of the preceding claims, configured, under the contact mode, to maintain a target distal end position with respect to a separate structure (68) while applying a target force at the distal end (8).

4. Motion compensating gangway according to one of the preceding claims, comprising a deployment mode, wherein under the deployment mode the control unit (40) is configured to control the distal end (8) position relative to the proximal end (4), based on at least the signal (44) from the motion reference unit (42), and/or any manual commands from an operator.

5. Motion compensating gangway according to one of the preceding claims, wherein the control unit (40) includes:

   a distal end setpoint determining section (48) for determining, under the contact mode, a distal end setpoint based on at least the signal (44) from the motion reference unit (42), and
   an actuator setpoint determining section (48) for determining, under the contact mode, an actuator setpoint for each actuator (26, 28, 30), based on at least the distal end setpoint and the signal (52) from the sensor (32).

6. A method for controlling a motion compensating gangway having a proximal end (4), a distal end (8), a walkway (2) between these, and one or more actuators (26, 28, 30) for moving the distal end (8) relative to the proximal end (4), the method comprising the steps of:

   determining a movement of the proximal end (4) which is a movement with respect to a fixed framework,
   determining a condition of contact between the distal end (8) and a separate structure (68),
   judging whether to operate the gangway in a contact mode based on the determined condition of contact, and
   when operating the gangway in the contact mode, driving the one or more actuators (26, 28, 30) based on at least the determined movement of the proximal end (4) and the determined condition of contact.

7. Method for controlling a motion compensating gangway, according to claim 6, comprising, when operating the gangway in the contact mode, the steps of:

   determining a distal end setpoint based on at least the determined movement of the proximal end (4),
   determining for each actuator (26, 28, 30), and based on at least the distal end setpoint and the determined condition of contact, a respective actuator setpoint, and
   driving each actuator (26, 28, 30) based on the respective actuator setpoint.

8. Method for controlling a motion compensating gangway, according to claim 6 or 7, wherein, when operating the gangway in the contact mode, the one or more actuators (26, 28, 30) are driven so that a target distal end position with respect to the separate structure (68) is maintained and simultaneously a target

force at the distal end (8) is applied.

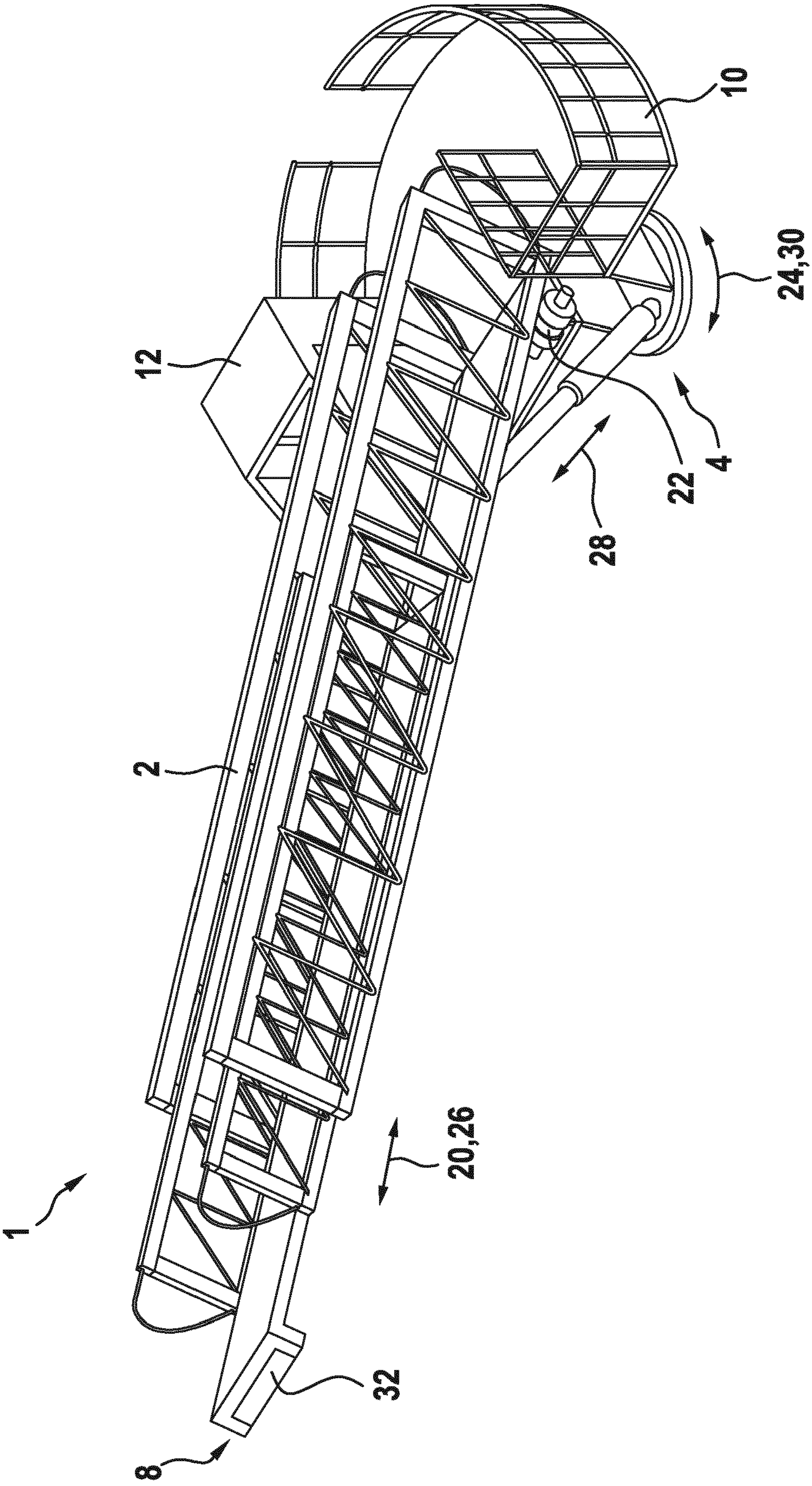

Fig. 1

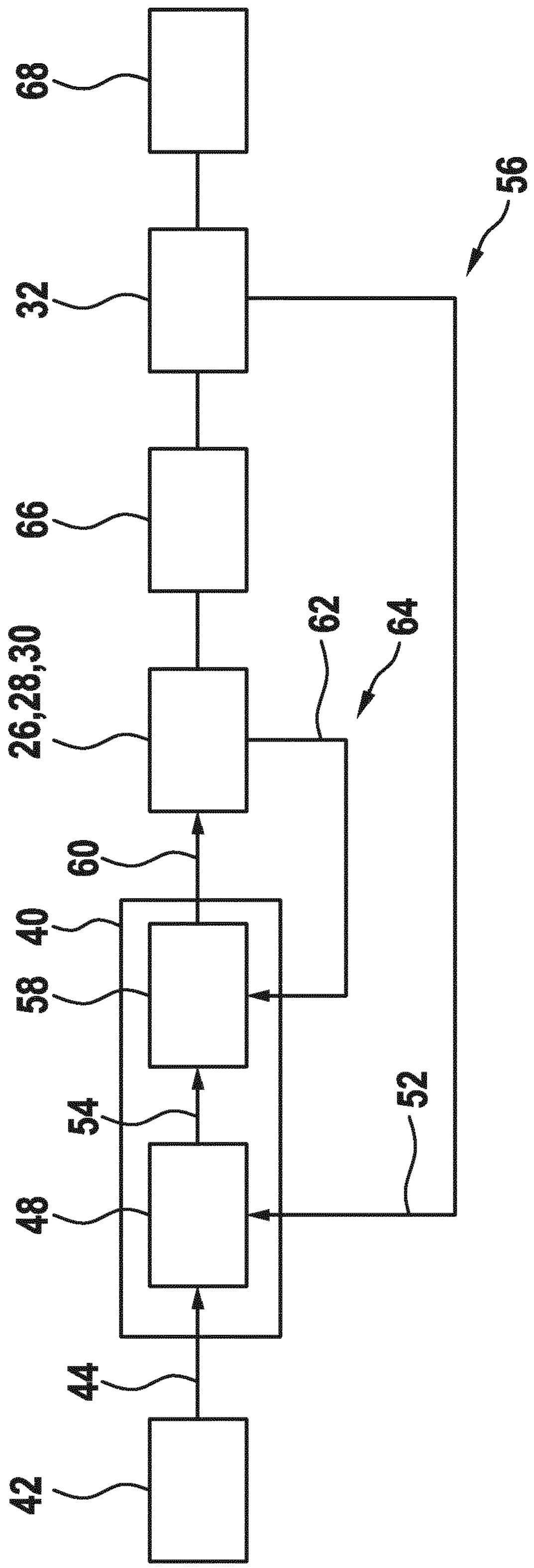

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 19 15 8191

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Place of search	Date of completion of the search	Examiner
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