Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a transfer assist apparatus, for example, a transfer assist apparatus that assists in a transfer operation for a person who cannot walk by oneself to transfer from a bed to a wheelchair or from the wheelchair to the toilet seat.

2. Description of the Related Art

[0002] For a care-receiver who cannot walk by oneself, it is not easy to perform by oneself the transfer movement of moving from a bed to a wheelchair. Usually, a nursing assistant has to help, but the aid in transfer movement places a large physical load on the nursing assistant and a large mental load on the care-receiver. Apparatuses that assist the transfer movement of a care-receiver who cannot walk by oneself have recently been developed. For example, Japanese Patent Application Publication No. 2006-305092 (JP-A-2006-305092) discloses a transfer assist apparatus in which a tiltable strut is provided in a raised condition on a rotatable platform and a receiving plate (holding device) is provided at the distal end of the strut. When the care-receiver has a transfer movement by using such a transfer assist apparatus, the strut is tilted and the receiving plate is brought close to the care-receiver’s body. Then, the care-receiver sets hands on the holding device, clutches the holding device, moves the body onto the receiving plate, and places the body weight thereon. Where the strut is then lifted, the care-receiver’s body is also lifted. After the transfer destination is reached, the strut is tilted to complete the transfer movement.

[0003] It is obviously an important problem to ensure safety of the care-receiver during the transfer assist. Japanese Patent Application Publication No. 8-191865 (JP-A-8-191865) and Japanese Patent Application Publication No. 7-016269 (JP-A-7-016269) disclose safety mechanisms in electric nursing lifts. Thus, JP-A-8-191865 discloses an electric nursing lift that hoists the care-receiver from a bed or lowers the care-receiver onto the bed, the lift having a structure such that the hoisting arm can be stretched and contracted. Therefore, even when the electric nursing lift is erroneously controlled and the care-receiver is inserted between the hoisting means and the floor, the hoisting arm is contracted to absorb the force acting upon the care-receiver. As a result, the care-receiver’s safety is reliably guaranteed.

[0004] JP-A-7-016269 discloses providing a bed with an aid arm that prevents tumbling and using a structure such that restricts the movement of the hoisting arm so as to allow the hoisting arm to rotate only when the aid arm protrudes to the outside of the bed. As a result, the bed is prevented from accidents such as overturning, and care-receiver’s safety is protected.

US 2003/0208844 A1 relates to a control apparatus and control method for a storable patient lift and transfer device.

[0005] A care-receiver that requires a transfer assist has disabled zones on the body, for example, a paralyzed half of the body or paralyzed legs and cognitive impairment. Therefore, significant sense of anxiety and fear are obviously associated with a transfer movement. Furthermore, during the transfer movement, the care-receiver with a disabled body has to entrust the entire own body to a nursing assistant or a nursing robot. The nursing assistant performs the aid and transfer assist, while listening to the care-receiver’s wishes, and the care-receiver’s sense of anxiety and fear can be mitigated based on the trust relationship between the nursing assistant and the care-receiver. However, when the transfer assist apparatus is used, the care-receiver can hardly trust the apparatus to the same extent as the nursing assistant and the sense of anxiety and fear grow additionally. One more problem associated with the transfer assist apparatus is the presence of various factors causing sense of anxiety and fear in the care-receiver, such as operation noise caused by a motor and gears, unpredictable abrupt acceleration, transfer trajectory undesirable for the care-receiver, and operation failures. Therefore, a transfer assist apparatus that can ensure not only the care-receiver’s safety, but also guarantee a sense of relief is highly desirable.

SUMMARY OF THE INVENTION

[0006] The intention provides a transfer assist apparatus that performs transfer assist, while reducing a sense of anxiety in the care-receiver.

[0007] A transfer assist apparatus according to a first aspect of the invention assists a care-receiver transfer. The apparatus includes: a movable carriage unit; an arm unit that includes a base end attached to the carriage unit and that rotates in a horizontal plane and tilted; a body holding device that is attached to the arm unit; a drive unit that drives the carriage unit and the arm unit; an operation unit into which a trajectory of the body holding device is inputted by a manual operation; and an anxiety measurement unit that detects a physical change linked to a sense of anxiety in the care-receiver and measures a degree of anxiety in the care-receiver; and a control unit that controls the drive unit correspond-
According to the above-described configuration, the anxiety measurement unit may detect at least one of a heart rate, an amount of perspiration, a breathing rate, an eyeball movement, an electric resistance of skin, and a skin temperature as the physical change linked to the sense of anxiety in the care-receiver.

The control unit may also set a speed limit that is an upper limit of a drive speed of the drive unit correspondingly to the degree of anxiety in the care-receiver that is measured by the anxiety measurement unit, and restrict the drive speed of the drive unit not to exceed the speed limit.

Furthermore, the control unit may set a gain that determines a response speed of the drive unit correspondingly to the degree of anxiety in the care-receiver that is measured by the anxiety measurement unit, and send a drive command to the drive unit by using the gain that is set. In the above-described configuration, the control unit may include a user database that stores, for each user, the degree of anxiety and a setting value to reduce the degree of anxiety.

The control unit may also include a data accumulation unit that accumulates, for each user, data when the transfer assist apparatus is used.

Furthermore, the control unit may set a feedback gain that minimizes an evaluation function that is based on a degree of anxiety in the care-receiver and a position and speed of the holding device, and use the set feedback gain in a position, speed, or acceleration feedback loop.

The transfer assist apparatus may further include an external output unit that outputs an anxiety representation signal that increases as the sense of anxiety in the care-receiver increases. The control unit generates the anxiety representation signal and outputs the signal to the external output unit to represent the sense of anxiety to an operator.

The external output unit may include a speaker or a vibrator attached to the operation unit and transmits the anxiety representation signal to an operator by sound or vibrations.

A transfer assist apparatus according to a second aspect of the invention assists a care-receiver transfer. The apparatus includes: a movable carriage unit; an arm unit that is attached to the carriage unit and that rotates in a horizontal plane and tilted; a body holding device that is attached to the arm unit; a drive unit that drives the carriage unit and the arm unit; an operation unit into which a trajectory of the body holding device is inputted by a manual operation; and a control unit that controls the drive unit correspondingly to the trajectory inputted by the operation unit, and performs a feedback control to reduce a degree of anxiety in the care-receiver by storing in advance a relief trajectory range, which is a trajectory range of the body holding device in which the care-receiver has a feeling of relief, sampling with a predetermined sampling pitch a trajectory of the body holding device that is inputted by an operator via the operation unit, comparing sampled coordinate data on the trajectory with the relief trajectory range, and when the sampled coordinate data is outside the relief trajectory range or when a point predicted based on sampled coordinate data within the relief trajectory range is predicted to be outside the relief trajectory range, correcting the trajectory of the body holding device to enter the relief trajectory range.

According to the above-described configuration, the control unit may correct, when the sampled coordinate data is outside the relief trajectory range or when the predicted point is predicted to be outside the relief trajectory range, a position of a point sampled immediately before the sampled coordinate data is sampled or the predicted point is predicted, or at least one point sampled before the sampled coordinate data is sampled or the predicted point is predicted, and generate a trajectory that is corrected such that a point predicted based on the corrected sampled position is within the relief trajectory range.

A transfer assist apparatus according to a third aspect of the invention assists a care-receiver transfer operation. The apparatus includes: a movable carriage unit; an arm unit that includes a base end attached to the carriage unit and that rotates in a horizontal plane and tilted; a body holding device that is attached to the arm unit; a drive unit that drives the carriage unit and the arm unit; an operation unit into which a trajectory of the body holding device is inputted by a manual operation; and a control unit that controls the drive unit correspondingly to the trajectory inputted by the operation unit, and performs a feedback control to reduce a degree of anxiety in the care-receiver by storing in advance a relief trajectory range, which is a trajectory range of the body holding device in which the care-receiver has a feeling of relief, sampling with a predetermined sampling pitch a trajectory of the body holding device that an operator inputs by the operation unit, comparing sampled coordinate data on the trajectory with the relief trajectory range, and when the sampled coordinate data is outside the relief trajectory range or when a point predicted based on sampled coordinate data within the relief trajectory range is predicted to be outside the relief trajectory range, instructing the operation unit to generate a reaction force in a direction that causes resistance to an input operation that inputs the trajectory that deviates from the relief trajectory range.

In the above-described configuration, the control unit may sample a trajectory of the body holding device by calculating from time to time a position of the body holding device on the basis of a drive amount of the drive unit.
The features, advantages, and technical and industrial significance of this invention will be described in the following detailed description of example embodiments of the invention with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a side view of the transfer assist apparatus according to the first embodiment of the invention;
FIG. 2 is a perspective view of the holding device according to the first embodiment;
FIG. 3 is a block diagram illustrating a system configuration of the transfer assist apparatus;
FIG. 4 is a functional block diagram of the control system according to the first embodiment;
FIG. 5 shows the relationship between a heart rate threshold and a speed limit;
FIG. 6 shows an example of setting a heartbeat sensor at a wrist and an ankle according to a variation example 1;
FIG. 7 shows a holding device having a microphone that detects a heart sound of the care-receiver according to a variation example 2;
FIG. 8 shows a variation example 3;
FIG. 9 shows a variation example 4;
FIG. 10 shows a variation example 5;
FIG. 11 shows a variation example 6;
FIG. 12 shows a variation example 7;
FIG. 13 shows an example in which an electrode is attached to a hand according to the variation example 7;
FIG. 14 shows another example in which an electrode is attached to a hand according to the variation example 7;
FIG. 15 shows an example in which a thermoster is attached to a hand according to the variation example 7;
FIG. 16 is a functional block diagram of the control system according to a second embodiment;
FIG. 17 is a functional block diagram of the control system according to a third embodiment;
FIG. 18 shows an example of accumulated data according to the third embodiment;
FIG. 19 shows another example of accumulated data according to the third embodiment;
FIG. 20 is a functional block diagram of the control system according to a fourth embodiment;
FIG. 21 shows an anxiety trajectory range and a relief trajectory range according to the fourth embodiment;
FIG. 22 shows a plurality of trajectories that connect a start point and a target point according to the fourth embodiment;
FIG. 23 shows an example of trajectory correction according to the fourth embodiment;
FIG. 24 shows an example of trajectory correction according to a variation example 8;
FIG. 25 is a functional block diagram of the control system according to a fifth embodiment;
FIG. 26 shows a state in which a reaction force is applied to an operation lever according to the fifth embodiment;
FIG. 27 is a functional block diagram of the control system according to a variation example 9;
FIG. 28 is a functional block diagram of the control system according to a sixth embodiment;
FIG. 29 is a functional block diagram of the control system according to a seventh embodiment; and
FIG. 30 shows the relationship between a heart rate (degree of anxiety) of the care-receiver and an anxiety representation signal according to the seventh embodiment.

Embodiments of the invention are illustrated by the appended drawings and will be explained with reference to numerals denoting various components.

(First Embodiment) The first embodiment of the invention will be explained below. FIG. 1 is a side view of a transfer assist apparatus according to the first embodiment of the invention. A transfer assist apparatus 10 is provided with a carriage unit 1, a robot arm unit 2 coupled to the carriage unit 1, and a holding device 3 attached to the robot arm unit 2.

The carriage unit 1 has a carriage body 11, a handle section 12 for pushing and moving the carriage unit 1, a pair of left and right front aid wheels 13 attached to the front portion of the carriage body 11, a pair of left and right rear aid wheels 14 attached to the rear portion of the carriage body 11, and a pair of left and right drive wheels 15 that are attached to a substantially central portion of the carriage body 11 and drive the carriage unit 1. A pair of left and right sixth motors 16 that drive the drive wheels 15 is coupled to the pair of left and right drive wheels 15.

The carriage unit 1 has a carriage body 11, a handle section 12 for pushing and moving the carriage unit 1, a pair of left and right front aid wheels 13 attached to the front portion of the carriage body 11, a pair of left and right rear aid wheels 14 attached to the rear portion of the carriage body 11, and a pair of left and right drive wheels 15 that are attached to a substantially central portion of the carriage body 11 and drive the carriage unit 1. A pair of left and right sixth motors 16 that drive the drive wheels 15 is coupled to the pair of left and right drive wheels 15.

The robot arm unit 2 is a multijoint arm that has a first arm section 21, a second arm section 22, and a third arm section 23. The first arm section 21 is coupled to a base section 11a of the carriage body 11 by a first joint section 51 so as to enable the rotation about a yaw axis and a pitch axis. The second arm section 22 is coupled to the first arm section 21 by a second joint section 52 to enable the rotation about the pitch axis. One end of the third arm section 23 is coupled to the second arm section 22 by a third joint section to enable the rotation about the pitch axis (the third joint section is not shown in FIG. 1 because it is located behind the third arm section and cannot be seen). The other end of
the third arm section 23 is coupled by a fourth joint section to an attachment section 24 for attaching the holding device 3 so as to enable the rotation about a roll axis (the fourth joint section is not shown in FIG. 1 because it is located inside the third arm section and cannot be seen). The attachment section 24 has a conventional attachment structure (for example, a tightening structure using a bolt and a nut or a fitting structure) that enables attachment and detachment of the holding device 3.

[0025] The yaw axis as referred to herein is a rotation axis of the first arm section 21 and extends in the vertical direction. The pitch axis as referred to herein is a rotation axis in a case where the first arm section 21, second arm section 22, and third arm section 23 rotate in the up-down direction. The roll axis as referred to herein is a rotation axis in a case where the attachment section 24 and the holding device 3 rotate with respect to the third arm section 23. The roll axis corresponds to the axial line of the third arm section 23.

[0026] A first motor (drive means) 61 that rotationally drives the first arm section 21 about the yaw axis is provided at the base section 11 a of the carriage body 11. A second motor (drive means) 62 that rotationally drives the first arm section 21 about the pitch axis is provided at the first joint section 51. A third motor (drive means) 63 that rotationally drives the second arm section 22 about the pitch axis is provided at the second joint section 52. A fourth motor (drive means) 64 that rotationally drives the third arm section 23 about the pitch axis is provided at the third joint section. A fifth motor (drive means) 65 that rotationally drives the attachment section 24 and holding device 3 about the roll axis is provided at the fourth joint section.

[0027] First to sixth motors 61, 62, 63, 64, 65, and 16 are connected via a drive circuit 18 to a control unit 17 and are rotationally driven by control signals from the control unit 17. Further, the base section 11a and joint sections (51, 52) are provided with rotation sensors 71, 72, 73, 74, and 75 that detect the rotational drive amount of the first to fifth motors 61, 62, 63, 64, and 65, respectively. The rotation sensors 71, 72, 73, 74, and 75 are connected to the control unit 17 and output the detected rotational drive amount to the control unit 17.

[0028] FIG. 2 is a perspective view of the holding device. The holding device 3 is attached to the attachment section 24 of the robot arm unit 2. The holding device 3 has a torso support section 31 that embraces and holds the care-receiver’s torso, a lower limb support section 32 that supports lower limbs of the care-receiver, and an anxiety detection sensor that detects a sense of anxiety in the care-receiver.

[0029] The lower limb support section 32 is formed in a substantially inverted T shape and connected to the lower portion of the torso support section 31. The torso support section 31 and lower limb support section 32 are configured integrally, but may be also configured as separate sections.

[0030] The torso support section 31 is provided with a chest support section 31a that comes into contact with the care-receiver’s chest, a pair of side surface support sections 31b that support the side surfaces of the chest, and a head support section 31c that supports a chin of a head.

[0031] The pair of side surface support sections 31b are formed opposite each other and extend in a substantially vertical direction from both side edges of the chest support section 31a. Further, the head support section 31c is formed as a convex portion on top of the chest support section 31a. The chest support section 31a, side surface support sections 31b, and head support section 31c are configured integrally, but may be also configured as separate sections.

[0032] The anxiety detection sensor is a heartbeat sensor 40 that detects the care-receiver’s heartbeat. Sensors of various systems such as an IR radiation system and an electric potential system can be used. The heartbeat sensor 40 is in the form of a belt attached to the chest area of the care-receiver and is provided at the torso support section 31. The sensor output of the heartbeat sensor 40 is outputted to an anxiety measurement unit 50. The anxiety measurement unit 50 processes the sensor signals from the anxiety detection sensor (heartbeat sensor 40) and outputs the sensor signals to the control unit 17 an anxiety signal. Examples of signal processing conducted in the anxiety measurement unit include counting the number of pulses in the sensor signal and calculating them as a heart rate per unit time, or conducting A/D conversion.

[0033] An anxiety measurement unit is constituted by the anxiety detection sensor (heartbeat sensor 40) and anxiety measurement unit.

[0034] FIG. 3 is a block diagram illustrating the system configuration of the transfer support apparatus. The control unit 17 that controls the rotational drive of the first to sixth motors 61, 62, 63, 64, 65, and 16 is provided at the carriage unit 1. The control unit 17 is mainly configured by a microprocessor having a Central Processing Unit (CPU) 17a that conducts control processing and computational processing, a Read Only Memory (ROM) 17b that stores a control program and a computational program that are executed by the CPU 17a, and a Random Access Memory (RAM) 17c that stores temporarily the processed data, and is also provided with an anxiety reduction control unit 100 that conducts feedback control to reduce the sense of anxiety in the care-receiver.

[0035] An operation section 25 that allows the nursing assistant to operate the transfer assist apparatus 10 is provided at the attachment section 24 of the robot arm unit 2. The operation section 25 is provided with an operation lever 25A and a force sensor 25B. The force sensor 25B detects operation corresponding to the size, direction, and momentum of the operation force applied to the operation lever 25A and outputs the operation signals to the control unit 17.

[0036] FIG. 4 is a detailed functional block diagram of a control system realized by the control unit 17. The control unit
17 realizes the functions of a trajectory generation unit 171, a target joint angle calculation unit 172, a synthesis unit 173, a motor speed command calculation unit 174, a speed limit unit 175, and an anxiety reduction control unit 100. The operation of each functional unit will be explained below together with the operation of the entire transfer assist apparatus 10.

[0037] When the transfer assist of the care-receiver is conducted, the nursing assistant performs an operation of moving the holding device 3 by using the operation unit 25. More specifically, the holding device 3 is moved close to the care-receiver's body. An operation signal from the operation unit 25 is provided to the trajectory generation unit 171. As a result, the trajectory generation unit 171 generates a trajectory of the holding device 3 corresponding to the operation signal. The generated trajectory is provided to the target joint angle calculation unit 172. The target joint angle calculation unit 172 finds the angles for the joint sections 51 and 52 to realize the generated trajectory by calculating the angles for each joint section 51, 52.

[0038] The calculated target joint angles are outputted to the synthesis means 173. Detection values from the rotation sensors 71 to 75 are also feedback sent to the synthesis means 173. The synthesis means 173 finds the difference between the target joint angle and the present motor revolution angle for each motor 61 to 65 and 16 and provides the found differences to the motor speed command calculation unit 174. The motor speed command calculation unit 174 multiplies the rotation angle difference by a predetermined gain and calculates a speed command that will be sent to each motor. The calculated motor speed command is provided to the motors 61 to 65 and 16 via the drive circuit 18. As a result, the arm unit 2 is driven by the motor drive, and the holding device 3 moves in front of the care-receiver's body along the trajectory and at the speed intended by the nursing assistant.

[0039] The care-receiver then grasps the holding device 3 that is in front of the care-receiver's body and moves to the holding device 3. After the care-receiver has moved to the holding device 3, the nursing assistant wounds the heartbeat sensor 40 serving as an anxiety detection sensor around the chest portion of the care-receiver to set the sensor. The heartbeat of the care-receiver is detected by the heartbeat sensor 40, and the sensor signal is outputted to the anxiety measurement unit 50. The degree of anxiety (heart rate) measured by the anxiety measurement unit 50 is provided to the anxiety reduction control unit 100.

[0040] The anxiety reduction control unit 100 of the embodiment that conducts the feedback control to reduce the sense of anxiety in the care-receiver will be explained below. The anxiety reduction control unit 100 is provided with a heart rate threshold storage unit (anxiety threshold storage unit) 101 that stores heart rate thresholds (anxiety thresholds) of several stages and a speed limit setting unit 102 that sets a speed limit of the motors corresponding to the heart rate threshold.

[0041] FIG. 5 shows a relationship between the heart rate threshold and the speed limit. A low anxiety threshold, a medium anxiety threshold, and a high anxiety threshold are set in the order from the lower heart rate as the heart rate thresholds. The speed limit of the motor revolution speed is set at several stages correspondingly to each threshold. Here, a first speed limit, a second speed limit, and a third speed limit are set correspondingly to the anxiety thresholds, and the settings are such that the higher is the heart rate (sense of anxiety), the lower is the speed limit.

[0042] The speed limit setting unit 102 sets an upper limit of a motor speed correspondingly to the care-receiver's heart rate provided from time to time from the anxiety degree measurement unit 50 and the thresholds stored in the heart rate threshold storage unit 101. For example, when the heart rate is between the low anxiety threshold and medium anxiety threshold, the first speed limit is the upper limit for the motor revolution speed.

[0043] The transfer assist device 10 has a plurality of motors 61 to 65 and 16, and thus settings of the speed limit may be conducted for each motor.

[0044] The speed limit unit 175 is provided between the motor speed command calculation unit 174 and the drive circuit 18, and the speed limit that has been set by the anxiety reduction control unit 100 is provided to the speed limit unit 175. The speed limit unit 175 sends a speed command to the drive circuit 18, such that the motor speed command does not exceed the speed limit, according to the set speed limit.

[0045] In a state in which such a control system functions, the nursing assistant raises the holding device 3 and lifts the care-receiver's body. In this case, the speed limit of the motor is set correspondingly to the care-receiver's heart rate, and the movement speed of the holding device 3 is automatically restricted. Where the sense of anxiety in the care-receiver intensifies, the movement speed of the holding device 3 is automatically decreased. As a result, even with a care-receiver who feels anxiety at a high movement speed, the movement speed is automatically restricted before the sense of anxiety becomes too strong. Therefore, the sense of anxiety is reduced.

[0046] After the nursing assistant has moved the holding device 3 together with the care-receiver to a transfer destination, the nursing assistance lowers the holding device 3 and gets the care-receiver off. The transfer assist operation is thereby completed.

[0047] With such a first embodiment, where the sense of anxiety in the care-receiver is increased to a predetermined value, the speed is automatically restricted. Therefore, the transfer assist can be performed that prevents the sense of anxiety in the care-receiver from raising to a fixed level or thereafter to reduce the sense of anxiety in the care-receiver.

[0048] (Variation Example 1) In the above-described first embodiment, a configuration is described by way of example
in which the heartbeat sensor 40 serving as an anxiety detection sensor is set in the chest area of the care-receiver, but it goes without saying that the blood flow or electrocardiogram can be measured from the outside. For example, as shown in FIG. 6, the heartbeat sensor 40 may be set at a wrist or an ankle. Because the care-receiver can be assumed to have various diseases, the position for detecting the heartbeat can be appropriately selected for each care-receiver.

(Variation Example 2) The heartbeat sensor is not limited to a configuration that senses the blood flow or electrocardiogram of the care-receiver and can also detect a heart sound. For example, as shown in FIG. 7, a microphone 41 that detects a heart sound of the care-receiver may be provided at a chest support section 31a of the holding device 3. Further, the anxiety measurement unit 50 converts the signals from the microphone 41 into a heart rate and provides it to the anxiety reduction control unit 100.

(Variation Example 3) A specific feature of the variation example 3 is in that a perspiration sensor 42 is used as the anxiety detection sensor that detects a sense of anxiety in the care-receiver. FIG. 8 is a side view illustrating a state in which the care-receiver is held in the holding device 3. A table section 31d protrudes at the rear surface side of the torso support section 31 of the holding device 3 (on the side of the torso support section 31 opposite from the care-receiver). A perspiration sensor 42 is provided on the upper surface of the table section 31d. Examples of devices suitable as the perspiration sensor 42 include a ventilation capsule sudorometer, a skin potential meter, and a moisture sensor. The care-receiver sitting in the holding device 3 places a hand on the table section 31d. As a result, the perspiration sensor 42 detects the amount of perspiration at the palm of the care-receiver’s hand.

(Variation Example 4) A specific feature of the variation example 4 is in that a piezoelectric sensor 43 that detects microvibrations of the care-receiver is used as the anxiety detection sensor that detects a sense of anxiety in the care-receiver. FIG. 9 is a side view illustrating a state in which the care-receiver is held in the holding device 3. The piezoelectric sensors 43 detect microvibrations of the human body caused by breathing. The threshold in the anxiety reduction control unit 100 has been set to a heart rate, but now a threshold based on the amount of perspiration is used.

(Variation Example 5) A variation example 5 will be explained below. A specific feature of the variation example 5 is in that a camera 44 that picks up the eyeball movement in the care-receiver is used as the anxiety detection sensor that detects a sense of anxiety in the care-receiver. FIG. 10 is a side view illustrating a state in which the care-receiver is held in the holding device 3. The camera 44 that picks up the image of the care-receiver’s face is provided on the upper surface of the holding device 3. Where the care-receiver sits in the holding device 3, the camera 44 picks up the image of the care-receiver’s face.

Because the image pickup camera 44 is used as the anxiety detection sensor, the configuration of the anxiety measurement unit 50 of the first embodiment is changed to measure a breathing rate from the sensor signal. The threshold in the anxiety reduction control unit 100 has been set to a heart rate, but now a threshold based on the breathing rate is used.

In such a configuration, as the sense of anxiety in the care-receiver grows, the breathing rate increases. The increase in the breathing rate is detected by the piezoelectric sensor 43 and the speed is automatically restricted correspondingly to the breathing rate. As a result, the sense of anxiety in the care-receiver is reduced.

In such a configuration, as the sense of anxiety in the care-receiver grows, the eyeballs of the care-receiver perform a specific movement. The eyeball movement is picked up by the pickup camera 44 and the speed is automatically calculated correspondingly to a degree to which the eyeball movement of the care-receiver and the pattern match. Alternatively, the variation rate of the eyeball movement may be also calculated as the degree of anxiety. The threshold in the anxiety reduction control unit 100 is based on the eyeball movement.
restricted correspondingly to the sense of anxiety. As a result, the sense of anxiety in the care-receiver is reduced.

0060] (Variation Example 6) A variation example 6 will be explained below. A specific feature of the variation example 6 is in that a current sensor 45 that detects an electric resistance of the care-receiver's skin is used as an anxiety detection sensor that detects a degree of anxiety in the care-receiver. FIG. 11 is a side view illustrating a state in which the care-receiver is held in the holding device 3. A table section 31d protrudes at the rear surface side of the torso support section 31 of the holding device 3 (on the side of the torso support section 31 opposite from the care-receiver). An electrode 45A serving as the current sensor 45 is provided on the upper surface of the table section 31d. The care-receiver seating in the holding device 3 places a hand on the table section 31d. By passing a weak electric current to the care-receiver's hand via the electrode 45A, the current sensor 45 detects the variation in electric resistance of the care-receiver's skin.

0061] Because the current sensor 45 is used as the anxiety detection sensor, the configuration of the anxiety measurement unit 50 of the first embodiment is changed to measure an electric resistance of skin from the sensor signal. The threshold in the anxiety reduction control unit 100 is based on the electric resistance of skin. An electric resistance of human skin is dependent on a level of strain (this is disclosed, for example, in http://www.ryohdohraku.com/index.html). In a strained state, when the sympathetic nerves are active, a current easily flows through the human body. In other words, the electric resistance decreases. Accordingly, when the speed limit is set in the speed limit setting unit 102, the speed limit is set correspondingly to the electric resistance of skin so that the upper limit speed of the motor decreases.

0062] In such a configuration, as the sense of anxiety in the care-receiver grows, the electric resistance of skin decreases. This decrease in the electric resistance is detected by the current sensor 45 and the speed is automatically restricted correspondingly to the electric resistance of skin. As a result, the sense of anxiety in the care-receiver is reduced.

0063] (Variation Example 7) A variation example 7 will be explained below. A specific feature of the variation example 7 is in that a temperature sensor 46 that detects a skin temperature of the care-receiver is used as an anxiety detection sensor that detects a degree of anxiety in the care-receiver. FIG. 12 is a side view illustrating a state in which the care-receiver is held in the holding device 3. A table section 31d protrudes at the rear surface side of the torso support section 31 of the holding device 3 (on the side of the torso support section 31 opposite from the care-receiver). The temperature sensor 46 is provided on the upper surface of the table section 31d.

0064] An electrode 46A may be used as the temperature sensor 46. In this case, as shown in FIG. 13 or 14, the electrode 46A is brought into contact with the care-receiver's hand. A thermistor 46B may also be used as the temperature sensor 46. In this case, as shown in FIG. 15, a temperature detection spot of the thermistor 46B may be pasted on a finger.

0065] Because the temperature sensor 46 is used as the anxiety detection sensor, the configuration of the anxiety measurement unit 50 of the first embodiment is changed to measure the skin temperature from the sensor signal. The threshold in the anxiety reduction control unit 100 is based on the skin temperature. The skin temperature of a human body depends on a level of strain, the skin temperature decreasing when a person is strained and increasing when the person is calm (relaxed). Accordingly, when the speed limit is set in the speed limit setting unit 102, the speed limit is set correspondingly to the decrease in skin temperature so that the upper limit speed of the motor decreases.

0066] In such a configuration, as the sense of anxiety in the care-receiver grows, the skin temperature decreases. The decrease in skin temperature is detected by the temperature sensor 46 and the speed is automatically restricted correspondingly to the skin temperature. As a result, the sense of anxiety in the care-receiver is reduced.

0067] (Second Embodiment) The second embodiment of the invention will be described below. The basic configuration of the second embodiment is similar to that of the first embodiment, but a specific feature of the second embodiment is that the motor speed is adjusted by adjusting a gain with the anxiety reduction control unit 110. FIG. 16 is a functional block diagram of the second embodiment. In the second embodiment, the speed limit unit 175 is not provided. Instead, the anxiety reduction control unit 110 is provided with a heart rate threshold recording unit 111 and a gain setting unit 112.

0068] Here, several stages are set for a heart rate threshold, and a gain that determines a response speed of the motor is set correspondingly to these thresholds at several stages. For example, the gain is set to decrease with the increase in a sense of anxiety (heart rate) correspondingly to the anxiety threshold (heart rate threshold).

0069] The gain setting unit 112 compares the heart rate of the care-receiver that is provided from time to time from the anxiety degree measurement unit 50 with each threshold stored in the heart rate threshold recording unit 111 and determines an upper limit value of gain. The gain set in the gain setting unit 112 is provided to the motor speed command calculation unit 174. The motor speed command calculation unit 174 uses the gain that has been set and calculates a speed command that will be provided to the motors 61 to 65 and 16. The speed command that has thus been found is provided to each motor via the drive circuit 18, and the holding device 3 moves along the trajectory indicated by the operation unit 25.

0070] Similarly to the first embodiment, in the second embodiment, the response of motors is delayed as the sense of anxiety in the care-receiver grows. Therefore, the movement speed of the holding device 3 is automatically delayed. As a result, even with a care-receiver who feels anxiety at a high movement speed, the movement speed is automatically reduced before the sense of anxiety becomes too strong, and the sense of anxiety is reduced.

0071] The above-described variation examples 1 to 7 can be applied to the second embodiment.

0072] (Third Embodiment) The third embodiment of the invention will be described below. The basic configuration of
the third embodiment is similar to that of the first embodiment, but a specific feature of the third embodiment is that optimum control is executed for each user. FIG. 17 is a functional block diagram of the third embodiment. In a case where one transfer assist apparatus 10 is shared by a plurality of care-receivers, reasons causing anxiety and degrees thereof differ among the care-receivers. In such a case, one control pattern should not be applied to all the care-receivers. Accordingly, in the third embodiment, the anxiety reduction control unit 100 is provided with a user database 200. Further, a data accumulation unit 300 is provided, and the sensor signals from the rotation sensors 71 to 75 and measurement values obtained with the anxiety measurement unit 50 are inputted in the data accumulation unit 300.

[0073] Anxiety thresholds (heart rate thresholds) and speed limit settings are recorded in association with a user ID in the user database 200. When the transfer assist apparatus 10 is used and the user ID of the care-receiver is inputted, the heart rate threshold and speed limit setting associated with the ID are read to the anxiety reduction control unit 100.

[0074] The data accumulation unit 300 accumulates data obtained when the transfer assist apparatus is used for each user. Examples of the accumulated data include a relationship between a motor speed and a degree of anxiety, such as shown in FIG. 18, and a relationship between a height of the holding device 3 and a degree of anxiety, such as shown in FIG. 19.

[0075] With such a configuration, when the transfer assist apparatus 10 is used, first, the user ID of the care-receiver is inputted. As a result, the heart rate threshold and speed limit setting associated with the ID are read to the anxiety reduction control unit 100. The anxiety reduction control unit 100 executes the control of anxiety reduction on the basis of the heart rate threshold and speed limit setting that have been read out. At the same time, the data accumulation unit 300 collects and accumulates data relating to the sense of anxiety inherent to the care-receiver.

[0076] With such a configuration, optimum anxiety reduction control can be executed for each user. Furthermore, because data relating to anxiety are collected for each user, the movement transfer comfortable for each user can be indicated.

[0077] It goes without saying that the above-described variation examples 1 to 7 can be applied to the third embodiment.

[0078] (Fourth Embodiment) The fourth embodiment of the invention will be described below. A specific feature of the fourth embodiment is in executing an automatic correction control producing a trajectory that creates a sense of relief in the care-receiver. FIG. 20 is a functional block diagram of the fourth embodiment. In the fourth embodiment, an anxiety reduction control unit 120 is provided with a trajectory sampling unit 124, a relief determination unit 125, and a trajectory correction unit 126.

[0079] Further, data relating to a relief trajectory range are recorded in a user database 210 in association with the user ID. As shown in FIG. 19, a relationship between a height of the holding device 3 and a degree of anxiety is collected in the data accumulation unit 300. Therefore, as shown in FIG. 21, an anxiety trajectory range $S_A$ in which the care-receiver feels anxiety and a relief trajectory range $S_R$ in which the care-receiver feels relaxed can be separated and found by setting an appropriate threshold for a degree of anxiety. The relief trajectory range $S_R$ found in the above-described manner is recorded as the relief trajectory range in the user database.

[0080] The control operation performed by the anxiety reduction control unit 120 will be explained below together with the operation of the entire transfer assist apparatus 10. In transfer assisting the care-receiver, the nursing assistant conducts an operation of moving the holding device 3 by using the operation unit 25. An operation signal from the operation unit 25 is provided to the trajectory generation unit 171. Accordingly, the trajectory generation unit 171 generates a trajectory of the holding device 3 that corresponds to the operation signal. The drive control of the motors 61 to 65 and 16 is executed according to the generated trajectory.

[0081] The trajectory sampling unit 124 conducts sampling with a predetermined sampling pitch of the trajectory generated in the trajectory generation unit 171. The sampled coordinate data is provided to the relief determination unit 125. The relief determination unit 125 compares the sampled coordinate data with the relief trajectory range. In a case where the sampled coordinate data is within the relief trajectory range, the processing relating to the sampled coordinate data within the relief trajectory range is completed and a transition is made to the processing of the next sampled point.

[0082] A plurality of routes connecting a start point and a target point can be considered as a trajectory indicated by the nursing assistant (operator). For example, a trajectory A, a trajectory B, and a trajectory C can be selected, as shown in FIG. 22. In this case, the trajectory B is within the relief trajectory range $S_R$, whereas the trajectory A and trajectory C are within the anxiety trajectory range $S_A$ and therefore undesirable. Accordingly, in a case where the inputted and instructed trajectory is within the anxiety trajectory range $S_A$, the trajectory correction unit 126 corrects the trajectory automatically so as to fit the trajectory into the relief trajectory range.

[0083] When the relief determination unit 125 determines that the coordinate data sampled in the trajectory sampling unit 124 is within the anxiety trajectory range $S_A$, the relief determination unit sends a trajectory correction instruction to the trajectory correction unit 126. Let us assume that the present location is $P(n)$ shown in FIG. 23. Then, for example, where the sampling point $P(n+1)$ enters the anxiety trajectory range $S_A$ as shown in FIG. 23, the trajectory has to be corrected. The trajectory correction unit 126 refers to the sampling point $P(n)$ that immediately precedes the sampling point $P(n+1)$ and is within the relief trajectory range $S_R$ and the next preceding sampling point $P(n-1)$. When a point obtained by correcting the point $P(n)$ is represented as a corrected point $P(n)'$ and a predicted point that is predicted on
an extending line connecting the point $P(n-1)$ and the corrected point $P(n)'$ is represented as $P(n+1)'$, the position of the corrected point $P(n)'$ is established such that the predicted point $P(n+1)'$ enters the relief trajectory range. The corrected point $P(n)'$ thus found is provided to the trajectory generation unit 171. The trajectory generation unit 171 corrects the trajectory by replacing the position of the point $P(n)$ with the corrected point $P(n)'$ obtained by correction in the trajectory correction unit 126. As a result, the trajectory of the holding device 3 in the transfer assist operation is fit in the relief trajectory range $S_R$.

[0084] The motor drive control is continued based on the trajectory that has thus been corrected.

[0085] The trajectory of the holding device 3 in the transfer assist operation is determined by the operation command of the nursing assistant, but it does not mean that the nursing assistant knows fully and at all times the range in which the care-receiver feels anxiety. Furthermore, however attentive is the nursing assistance, operation errors are still possible. Accordingly, in the embodiment, a sense of anxiety in the care-receiver is reduced by automatically correcting the trajectory in a range in which the care-receiver can have a feeling of relief.

[0086] (Variation Example 8) In the fourth embodiment a case is explained by way of example in which the trajectory of one preceding point enters the anxiety trajectory range $S_A$, but because of the relationship between a sampling pitch of the CPU 17a and a motor speed, the correction of one sampling point can cause too abrupt changes. In such a case, the positions of a plurality of sampling points may be corrected as shown in FIG. 24. Thus, in FIG. 24, the positions of corrected points $P(n)'$ to $P(n+3)'$ are established such that the estimated point (for example, $P(n+4)'$) that is several points in front of the point $P(n)$ is within the relief trajectory range. The predicted point that takes into account a plurality of points in front may be calculated by linking vectors connected to an immediately preceding point and also, for example, by using an approximation curve such as a Bezier curve.

[0087] (Fifth Embodiment) The fifth embodiment of the invention will be described below. A specific feature of the fifth embodiment is that a reaction force is applied to the lever 25A of the operation unit 25 when an inputted and instructed trajectory is within the anxiety trajectory range. FIG. 25 is a functional block diagram illustrating the fifth embodiment. In the fifth embodiment, the anxiety reduction control unit 130 is provided with a trajectory sampling unit 134, a relief determination unit 135, and a reaction force command unit 137.

[0088] The trajectory sampling unit 134 samples the trajectory generated in the trajectory generation unit 171. The relief determination unit 135 determines whether the sampling point is within the relief trajectory range $S_R$. When the relief determination unit 135 determines that the coordinate data sampled in the trajectory sampling unit 134 has entered the anxiety trajectory range $S_A$, the relief determination unit issues an instruction to generate a reaction force to the reaction force command unit 137.

[0089] The reaction force command unit 137 sends a command to generate a reaction force in a direction that causes a sensation of resistance to an input operation in which the trajectory is within the anxiety trajectory range $S_A$ and sends the command to the operation unit 25. For example, in a case where a transition to the anxiety trajectory range $S_A$ is made in the sampling point $P(n+1)$, similarly to the fourth embodiment, the operator feels a resistance to the operation of shifting the operation lever 25A up. Thus, upon receiving the reaction force generation command from the reaction force command unit 137, the operation unit 25 produces a reaction force directed from the top down, as shown in FIG. 26.

[0090] With such a configuration, the nursing assistant (operator) feels a resistance when a trajectory is to be inputted that makes the care-receiver anxious. As a result, a feedback designed to return the trajectory into the relief trajectory range $S_R$ is provided to the nursing assistance (operator). Therefore a sense of anxiety in the care-receiver is reduced.

[0091] (Variation Example 9) In the above-described fourth embodiment, the variation example 8, and the fifth embodiment, a case is explained by way of example in which the trajectory sampling units 124 and 134 sample the trajectories generated in the trajectory generation unit 171. By contrast, in variation example 9, as shown in FIG. 27, the output of rotation sensors 71 to 75 may be inputted to a trajectory sampling unit 144. The trajectory sampling unit 144 calculates from time to time the present position of the holding device 3 on the basis of the output of rotation sensors 71 to 75. Further, the next point is predicted based on the several past points. For example, the next point $P(n+1)$ may be predicted by extending a vector connecting the point $P(n-1)$ and the point $P(n)$, or a point in front may be predicted by applying a curve approximation such as a Bezier curve to a plurality of past points. The predicted points that have thus been found are provided to the relief determination unit 145. Such a configuration also makes it possible to correct the trajectory automatically to a range in which the care-receiver can have a sense of relief. Therefore, the sense of anxiety in the care-receiver is reduced.

[0092] (Sixth Embodiment) The sixth embodiment of the invention will be described below. A specific feature of the sixth embodiment is that a feedback gain is adjusted so as to minimize an evaluation function based on a sense of anxiety. FIG. 28 is a functional block diagram of the sixth embodiment. In the sixth embodiment an anxiety reduction control unit 150 has a feedback gain setting unit 158. A gain multiplication unit 400 is provided in a loop from the rotation sensors 71 to 75 to a synthesis means 173.

[0093] Sensor values for the rotation sensors 71 to 75 and measured values of a degree of anxiety that have been measured in the anxiety measurement unit 50 are inputted to the anxiety reduction control unit 150. The feedback gain setting unit 158 of the anxiety reduction control unit 150 sets the gain of the gain multiplication unit 400. For example,
an optimum regulator can be used as a means for adjusting the gain. A model for setting a feedback gain as an optimum regulator will be explained below.

The degree of anxiety in the care-receiver is modeled by the following Equation (1).

\[
\dot{a} = r \cdot v + q \cdot h + 0 \cdot a
\]

Here, a stands for a degree of anxiety, a dot above a means a first-order derivative of the degree of anxiety. v stands for a speed of the holding device 3, h stands for a height of the holding device 3, r and q stand for weight coefficients. Where the speed v and height h are vectors, a positive-definite matrix is obtained.

[v, h, a] is a state variation and a state equation of the transfer assist apparatus 10 can be represented as follows.

\[
\frac{d}{dx} \begin{bmatrix} v \\ h \\ a \end{bmatrix} = \begin{bmatrix} a_1 & a_2 & 0 \\ a_3 & a_4 & 0 \\ r & q & 0 \end{bmatrix} \begin{bmatrix} v \\ h \\ a \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}u
\]

A feedback gain as an optimum regulator is found by solving the Riccati equation with respect to Equation (2) above. Equation (2) is represented as follows.

\[
\dot{x} = Ax + Bu
\]

In this case, the following equation is solved.

\[
PA + A^T P - PBR^{-1}B^T P + Q = 0
\]

Where P is taken as a positive constant, the feedback gain can be represented as follows.

\[
K(t) = R^{-1}B^T P(t)
\]

In a case where the control system of the transfer assist apparatus is a nonlinear feedback system in which a coefficient varies with time, the optimum feedback gain has to be sequentially computed.

The gain K that has thus been calculated is set as a gain of the gain multiplication unit 400. As a result, the feedback is automatically applied so as to reduce the sense of anxiety in the care-receiver that is associated with the height h and speed v of the holding device 3, and the sense of anxiety in the care-receiver is reduced.

(Seventh Embodiment) The seventh embodiment of the invention will be explained below. A specific feature of the seventh embodiment is that the operator (nursing assistant) is notified to the effect that the care-receiver has a sense of anxiety. FIG. 29 is a functional block diagram of the seventh embodiment. In the seventh embodiment, an anxiety reduction control unit 160 is provided with an anxiety representation signal generation unit 169. Further, an anxiety representation signal generated in the anxiety representation signal generation unit 169 is outputted in the form of a sound or vibrations from an external output unit 500.

A speaker or a vibrator can be used as the external output unit 500. It is preferred that the anxiety representation signal that is linked to the sense of anxiety in the care-receiver be not transmitted to the care-receiver himself. Otherwise, the sense of anxiety in the care-receiver can be augmented. For example, a small speaker may be provided at the distal
end of the operation lever 25A so that the anxiety representation signal may be heard only by the operator (nursing assistant). Alternatively, a vibrator may be incorporated in the operation lever 25A and vibrations may be transmitted to the hand of the operator (nursing assistant).

[0106] In such a configuration, the operator is notified about the sense of anxiety felt by the care-receiver. In a case where the anxiety representation signal gradually increases and then rapidly increases, measures can be taken to alleviate the sense of anxiety in the care-receiver. For example, the care-receiver can be spoken to, the movement can be slowed down, and the trajectory can be changed so as to avoid excess increase in height. As a result, the sense of anxiety in the care-receiver can be reduced.

[0107] It goes without saying that the above-described variation examples 1 to 7 can be similarly applied to the seventh embodiment.

[0108] The invention is not limited to above-described embodiments and can be variously changed without departing from the scope of the invention. For example, in the embodiments a case is explained in which a threshold is set for a degree of anxiety and the speed limit or gain is decreased in a stepwise manner. However, it goes without saying that the upper limit of the speed limit or gain may be changed continuously in response to the degree of anxiety. The system configuration of the above-described embodiments involves only the position feedback, but a speed or acceleration feedback may be also used.

Claims

1. A transfer assist apparatus that assists a care-receiver transfer, comprising:
   a movable carriage unit (1);
   an arm unit (2) that includes a base end attached to the carriage unit and that rotates in a horizontal plane and tilted;
   a body holding device (3) that is attached to the arm unit;
   a drive unit (61,62,63,64,65) that drives the carriage unit and the arm unit;
   an operation unit (25) into which a trajectory of the body holding device is inputted by a manual operation; and
   an anxiety measurement unit (50) that detects a physical change linked to a sense of anxiety in the care-receiver and measures a degree of anxiety in the care-receiver;

2. The transfer assist apparatus according to claim 1, wherein:
   the anxiety measurement unit (50) detects at least one of a heart rate, an amount of perspiration, a breathing rate, an eyeball movement, an electric resistance of skin, and a skin temperature as the physical change linked to the sense of anxiety in the care-receiver.

3. The transfer assist apparatus according to claim 1 or 2, wherein
   the control unit (17) sets a speed limit that is an upper limit of a drive speed of the drive unit (61,62,63,64,65) correspondingly to the degree of anxiety in the care-receiver that is measured by the anxiety measurement unit (50), and restricts the drive speed of the drive unit not to exceed the speed limit.

4. The transfer assist apparatus according to claim 1 or 2, wherein
   the control unit (17) sets a gain that determines a response speed of the drive unit (61,62,63,64,65) correspondingly to the degree of anxiety in the care-receiver that is measured by the anxiety measurement unit (50), and sends a drive command to the drive unit by using the gain that is set.

5. The transfer assist apparatus according to claim 4, wherein
   the control unit (17) sets the gain to decrease as the degree of anxiety in the care-receiver increases.

6. The transfer assist apparatus according to any of claims 1 to 5, wherein
   the control unit (17) includes a user database (200) that stores, for each user, the degree of anxiety and a setting value to reduce the degree of anxiety.

7. The transfer assist apparatus according to claim 6, wherein
   the setting value includes a speed limit that is an upper limit of a drive speed of the drive unit and is set correspondingly
8. The transfer assist apparatus according to any of claims 1 to 7, wherein
   the control unit (17) includes a data accumulation unit (300) that accumulates, for each user, data when the transfer
   assist apparatus is used.

9. The transfer assist apparatus according to claim 8, wherein
   the accumulated data include, for each user, a relationship between the degree of anxiety and the drive speed of
   the driver unit and a relationship between the degree of anxiety and a position of the body holding device.

10. The transfer assist apparatus according to claim 1 or 2, wherein
    the control unit (17) sets a feedback gain that minimizes an evaluation function that is based on a degree of anxiety
    in the care-receiver and a position and speed of the body holding device, and uses the set feedback gain in a
    position, speed, or acceleration feedback loop.

11. The transfer assist apparatus according to claim 1 or 2, further comprising
    an external output unit (500) that outputs an anxiety representation signal that increases as the sense of anxiety in
    the care-receiver increases, wherein
    the control unit (17) generates the anxiety representation signal and outputs the signal to the external output unit
    to represent the sense of anxiety to an operator.

12. The transfer assist apparatus according to claim 11, wherein
    the external output unit (500) includes a speaker or a vibrator attached to the operation unit and transmits the anxiety
    representation signal to an operator by sound or vibrations.

13. A transfer assist apparatus that assists a care-receiver transfer, comprising:

    a movable carriage unit (1);
    an arm unit (2) that is attached to the carriage unit and that rotates in a horizontal plane and tilted;
    a body holding device (3) that is attached to the arm unit;
    a drive unit (61,62,63,64,65) that drives the carriage unit and the arm unit;
    an operation unit (25) into which a trajectory of the body holding device is inputted by a manual operation; and
    a control unit (17) that controls the drive unit correspondingly to the trajectory inputted by the operation unit,
    and performs a feedback control to reduce a degree of anxiety in the care-receiver by storing in advance a relief
    trajectory range, which is a trajectory range of the body holding device in which the care-receiver has a feeling
    of relief, sampling with a predetermined sampling pitch a trajectory of the body holding device that is inputted
    by an operator via the operation unit, comparing sampled coordinate data on the trajectory with the relief
    trajectory range, and when the sampled coordinate data is outside the relief trajectory range or when a point
    predicted based on sampled coordinate data within the relief trajectory range is predicted to be outside the relief
    trajectory range, correcting the trajectory of the body holding device to enter the relief trajectory range.

14. The transfer assist apparatus according to claim 13, wherein
    the control unit (17) corrects, when the sampled coordinate data is outside the relief trajectory range or when the
    predicted point is predicted to be outside the relief trajectory range, a position of a point sampled immediately before
    the sampled coordinate data is sampled or the predicted point is predicted, or at least one point sampled before the
    sampled coordinate data is sampled or the predicted point is predicted, and generates a trajectory that is corrected
    such that a point predicted based on the corrected sampled position is within the relief trajectory range.

15. A transfer assist apparatus that assists a care-receiver transfer, comprising:

    a movable carriage unit (1);
    an arm unit (2) that includes a base end attached to the carriage unit and that rotates in a horizontal plane and
    tilted;
    a body holding device (3) that is attached to the arm unit;
    a drive unit (61,62,63,64,65) that drives the carriage unit and the arm unit;
    an operation unit (25) into which a trajectory of the body holding device is inputted by a manual operation; and
    a control unit (17) that controls the drive unit correspondingly to the trajectory inputted by the operation unit,
    and performs a feedback control to reduce a degree of anxiety in the care-receiver by storing in advance a relief
trajectory range, which is a trajectory range of the body holding device in which the care-receiver has a feeling of relief, sampling with a predetermined sampling pitch a trajectory of the body holding device that an operator inputs by the operation unit, comparing sampled coordinate data on the trajectory with the relief trajectory range, and when the sampled coordinate data is outside the relief trajectory range or when a point predicted based on sampled coordinate data within the relief trajectory range is predicted to be outside the relief trajectory range, instructing the operation unit to generate a reaction force in a direction that causes resistance to an input operation that inputs the trajectory that deviates from the relief trajectory range.

16. The transfer assist apparatus according to any of claims 13 to 15, wherein:

the control unit (17) samples a trajectory of the body holding device by calculating from time to time a position of the body holding device on the basis of a drive amount of the dive unit.

17. The transfer assist apparatus according to claim 13 or 16, wherein:

the control unit (17) includes a user database that stores, for each user, the relief trajectory range.

Patentansprüche

1. Transferhilfsgerät, das einen Pflegeempfängertransfer unterstützt, wobei das Gerät Folgendes aufweist:

eine bewegliche Transporteinheit (1);
eine Armeinheit (2), die ein Basisende umfasst, das an der Transporteinheit angebracht ist, und die in einer horizontalen Ebene rotiert und geneigt wird;
eine Körperhaltevorrichtung (3), die an der Armeinheit angebracht ist;
eine Antriebseinheit (61, 62, 63, 64, 65), die die Transporteinheit und die Armeinheit antriebt;
eine Betriebseinheit (25), in die eine Bewegungsbahn der Körperhaltevorrichtung durch einen manuellen Betrieb eingegeben wird; und
eine Angstmessungseinheit (50), die eine körperliche Änderung erfasst, die mit einem Gefühl von Angst des Pflegeempfängers verknüpft ist, und einen Grad von Angst des Pflegeempfängers gemessen wird;
eine Steuereinheit (17), die die Antriebseinheit entsprechend der Bewegungsbahn, die durch die Betriebseinheit eingegeben ist, steuert und eine Regelung durchführt, um den Grad von Angst, der durch die Angstmessungseinheit gemessen wird, zu reduzieren.

2. Transferhilfsgerät gemäß Anspruch 1, wobei:
die Angstmessungseinheit (50) mindestens einen Parameter von einer Herzfrequenz, einer Menge eines Schwitzens, einer Atemfrequenz, einer Augapfelbewegung, einem elektrischen Widerstand von Haut und einer Hauttemperatur als die körperliche Änderung erfasst, die mit dem Gefühl von Angst des Pflegeempfängers verknüpft ist.

3. Transferhilfsgerät gemäß Anspruch 1 oder 2, wobei
die Steuereinheit (17) eine Geschwindigkeitsgrenze, die eine obere Grenze einer Antriebsgeschwindigkeit der Antriebseinheit (61, 62, 63, 64, 65) ist, entsprechend zu dem Grad von Angst des Pflegeempfängers, der durch die Angstmessungseinheit (50) gemessen wird, festlegt und die Antriebsgeschwindigkeit der Antriebseinheit begrenzt, um die Geschwindigkeitsgrenze nicht zu übersteigen.

4. Transferhilfsgerät gemäß Anspruch 1 oder 2, wobei
die Steuereinheit (17) eine Verstärkung, die eine Antwortgeschwindigkeit der Antriebseinheit (61, 62, 63, 64, 65) bestimmt, entsprechend zu dem Grad von Angst des Pflegeempfängers, der durch die Angstmessungseinheit (50) gemessen wird, festlegt und einen Antriebsbefehl an die Antriebseinheit unter Einsatz der Verstärkung, die festgelegt ist, sendet.

5. Transferhilfsgerät gemäß Anspruch 4, wobei
die Steuereinheit (17) die Verstärkung festlegt, um sich zu verringern, wenn sich der Grad von Angst des Pflegeempfängers erhöht.
6. Transferhilfsgerät gemäß einem der Ansprüche 1 bis 5, wobei
die Steuereinheit (17) eine Benutzerdatenbasis (200) umfasst, die für jeden Benutzer den Grad von Angst und einen
Einstellungswert speichert, um den Grad von Angst zu reduzieren.

7. Transferhilfsgerät gemäß Anspruch 6, wobei
der Einstellungswert eine Geschwindigkeitsgrenze umfasst, die eine obere Grenze einer Antriebsgeschwindigkeit
der Antriebseinheit ist und entsprechend dem Grad von Angst festgelegt ist.

8. Transferhilfsgerät gemäß einem der Ansprüche 1 bis 7, wobei
die Steuereinheit (17) eine Datenspeichereinheit (300) umfasst, die für jeden Benutzer Daten speichert, wenn das
Transferhilfsgerät verwendet wird.

9. Transferhilfsgerät gemäß Anspruch 8, wobei
die gespeicherten Daten für jeden Benutzer eine Beziehung zwischen dem Grad von Angst und der Antriebsge-
schwindigkeit der Antriebseinheit und eine Beziehung zwischen dem Grad von Angst und einer Position der Kör-
perhaltevorrichtung umfassen.

10. Transferhilfsgerät gemäß Anspruch 1 oder 2, wobei
die Steuereinheit (17) eine Rückkopplungsverstärkung festlegt, die eine Bewertungsfunktion minimiert, die auf einem
Grad von Angst des Pflegeempfängers und einer Position und einer Geschwindigkeit der Körperhaltevorrichtung
basiert, und die festgelegte Rückkopplungsverstärkung in einer Positions-, einer Geschwindigkeits- oder einer
Beschleunigungsrückkopplungsschleife verwendet.

11. Transferhilfsgerät gemäß Anspruch 1 oder 2, des Weiteren mit
einer externen Ausgabeeinheit (500), die ein Angstdarstellungssignal ausgibt, das sich erhöht, wenn sich das Gefühl
von Angst des Pflegeempfängers erhöht, wobei
die Steuereinheit (17) das Angstdarstellungssignal erzeugt und das Signal zu der externen Ausgabeeinheit ausgibt,
um das Gefühl von Angst einer Bedienperson darzustellen.

12. Transferhilfsgerät gemäß Anspruch 11, wobei
die externe Ausgabeeinheit (500) einen Lautsprecher oder einen Vibrator umfasst, der an der Betriebseinheit an-
gebracht ist, und das Angstdarstellungssignal an einen Betreiber durch Geräusch oder Vibrationen übermittelt.

13. Transferhilfsgerät, das einen Pflegeempfängertransfer unterstützt, wobei das Gerät Folgendes aufweist:
eine bewegliche Transporteinheit (1);
eine Armeinheit (2), die an der Transporteinheit angebracht ist und die in einer horizontalen Ebene rotiert und
geneigt wird;
eine Körperhaltevorrichtung (3), die an der Armeinheit angebracht ist;
eine Antriebseinheit (61, 62, 63, 64, 65), die die Transporteinheit und die Armeinheit antreibt;
eine Betriebseinheit (25), in die eine Bewegungsbahn der Körperhaltevorrichtung durch einen manuellen Betrieb
g eingegeben wird; und
eine Steuereinheit (17), die die Antriebseinheit entsprechend der Bewegungsbahn, die durch die Betriebs-
einheit eingegeben ist, steuert und eine Regelung durchführt, um einen Grad von Angst des Pflegeempfängers
durch eine Speicherung eines Erleichterungsbewegungsbahnbereichs im Voraus, der eine Bewegungsbahnbe-
reich der Körperhaltevorrichtung ist, in dem der Pflegeempfänger eine Empfindung von Erleichterung hat, durch
ein Abfragen mit einem vorbestimmten Abfrageabstand einer Bewegungsbahn der Körperhaltevorrichtung, die
durch einen Betreiber über die Betriebseinheit eingegeben ist, durch ein Vergleichen abgefragter Koordinatendaten
auf der Bewegungsbahn mit dem Erleichterungsbewegungsbahnbereich, und, wenn die abgefragten
Koordinatendaten außerhalb des Erleichterungsbewegungsbahnbereichs sind oder wenn ein Punkt, der basie-
rend auf abgefragten Koordinatendaten innerhalb des Erleichterungsbewegungsbahnbereichs vorausgesagt
ist, außerhalb des Erleichterungsbewegungsbahnbereichs vorausgesagt ist, durch eine Korrektur der Bewei-
gungsbahn der Körperhaltevorrichtung, um den Erleichterungsbewegungsbahnbereich zu betreten, zu redu-
zieren.

14. Transferhilfsgerät gemäß Anspruch 13, wobei
die Steuereinheit (17), wenn die abgefragten Koordinatendaten außerhalb des Erleichterungsbewegungsbahnbere-
ichs sind oder wenn der vorausgesagte Punkt als außerhalb des Erleichterungsbewegungsbahnbereichs liegend
vorausgesagt ist, eine Position eines Punktes, der unmittelbar vor Abfragen der abgefragten Koordinatendaten oder vor Voraussage des vorausgesagten Punktes abgefragt wird, oder mindestens eines Punktes, der vor Abfragen der abgefragten Koordinatendaten oder vor Voraussage des vorausgesagten Punktes abgefragt wird, korrigiert und eine Bewegungsbahn erzeugt, die derart korrigiert ist, dass ein Punkt, der basierend auf der korrigierten abgefragten Position vorausgesagt ist, innerhalb des Erleichterungsbewegungsbahnbereichs ist.

15. Transferhilfsvorrichtung, das einen Pflegeempfängertransfer unterstützt, wobei das Gerät Folgendes aufweist:

eine bewegliche Transporteinheit (1);
eine Armeinheit (2), die ein Basisende umfasst, das an der Transporteinheit angebracht ist, und die in einer horizontalen Ebene rotiert und geneigt wird;
eine Körperhaltevorrichtung (3), die an der Armeinheit angebracht ist;
eine Antriebseinheit (61, 62, 63, 64, 65), die die Transporteinheit und die Armeinheit antreibt;
eine Betriebseinheit (25), in der eine Bewegungsbahn der Körperhaltevorrichtung durch einen manuellen Betrieb eingegeben wird; und
eine Steuereinheit (17), die die Betriebseinheit entsprechend zu der Bewegungsbahn, die durch die Betriebsseinheit eingegeben ist, steuert und eine Regelung durchführt, um einen Grad von Angst des Pflegeempfängers durch eine Speicherung eines Erleichterungsbewegungsbahnbereichs im Voraus, der ein Bewegungsbahnbereich der Körperhaltevorrichtung ist, in dem der Pflegeempfänger eine Empfindung von Erleichterung hat, durch ein Abfragen mit einem vorbestimmten Abfrageabstand einer Bewegungsbahn der Körperhaltevorrichtung, die ein Betreiber durch die Betriebseinheit eingibt, durch ein Vergleichen abgefragter Koordinatendaten auf der Bewegungsbahn mit dem Erleichterungsbewegungsbahnbereich, und, wenn die abgefragten Koordinatendaten außerhalb des Erleichterungsbewegungsbahnbereichs sind oder wenn ein Punkt, der basierend auf abgefragten Koordinatendaten innerhalb des Erleichterungsbewegungsbahnbereichs vorausgesagt ist, als außerhalb des Erleichterungsbewegungsbahnbereichs liegend vorausgesagt ist, durch ein Anweisen der Betriebseinheit, um eine Reaktionskraft in einer Richtung zu erzeugen, die einen Widerstand zu einem Eingabebetrieb bewirkt, der die Bewegungsbahn eingeht, die von dem Erleichterungsbewegungsbereich abweicht, zu reduzieren.

16. Transferhilfsgerät gemäß einem der Ansprüche 13 bis 15, wobei:
die Steuereinheit (17) eine Bewegungsbahn der Körperhaltevorrichtung durch Berechnung einer Position der Körperhaltevorrichtung von Zeit zu Zeit auf der Basis eines Antriebsbetrags der Betriebseinheit abfragt.

17. Transferhilfsgerät gemäß Anspruch 13 oder 16, wobei:
die Steuereinheit (17) eine Benutzerdatenbank umfasst, die für jeden Benutzer den Erleichterungsbewegungsbereich speichert.

Revendications

1. Appareil d’aide au transfert, qui aide au transfert d’une personne recevant des soins, comprenant :

   une unité de chariot mobile (1) ;
   une unité de bras (2) qui comprend une extrémité de base attachée à l’unité de chariot et qui tourne dans un plan horizontal et incliné ;
   un dispositif de maintien de corps (3) qui est attaché à l’unité de bras ;
   une unité d’entraînement (61, 62, 63, 64, 65) qui entraîne l’unité de chariot et l’unité de bras ;
   une unité d’opérations (25) dans laquelle une trajectoire du dispositif de maintien de corps est entrée par une opération manuelle ; et
   une unité de mesure d’anxiété (50) qui détecte un changement physique lié à un sentiment d’anxiété de la personne recevant des soins et qui mesure un degré d’anxiété de la personne recevant des soins ; et
   une unité de commande (17) qui commande l’unité d’entraînement en correspondance avec la trajectoire entrée par l’unité d’opérations et qui effectue une commande à rétroaction de manière à réduire le degré d’anxiété mesuré par l’unité de mesure d’anxiété.

2. Appareil d’aide au transfert selon la revendication 1, dans lequel :

l’unité de mesure d’anxiété (50) détecte au moins l’un d’un rythme cardiaque, d’une quantité de transpiration, d’un rythme respiratoire, d’un mouvement de globe oculaire, d’une résistance électrique de la peau et d’une température de la peau en tant que changement physique lié au sentiment d’anxiété de la personne recevant des soins.

3. Appareil d’aide au transfert selon la revendication 1 ou 2, dans lequel l’unité de commande (17) fixe une limite de vitesse qui est une limite supérieure d’une vitesse d’entraînement de l’unité d’entraînement (61, 62, 63, 64, 65) en correspondance avec le degré d’anxiété de la personne recevant des soins qui est mesuré par l’unité de mesure d’anxiété (50), et limite la vitesse d’entraînement de l’unité d’entraînement de manière à ne pas dépasser la limite de vitesse.

4. Appareil d’aide au transfert selon la revendication 1 ou 2, dans lequel l’unité de commande (17) fixe un gain qui détermine une vitesse de réponse de l’unité d’entraînement (61, 62, 63, 64, 65) en correspondance avec le degré d’anxiété de la personne recevant des soins qui est mesuré par l’unité de mesure d’anxiété (50), et envoie une commande d’entraînement à l’unité d’entraînement en utilisant le gain qui est fixé.

5. Appareil d’aide au transfert selon la revendication 4, dans lequel l’unité de commande (17) fixe le gain pour qu’il diminue alors que le degré d’anxiété de la personne recevant des soins augmente.

6. Appareil d’aide au transfert selon l’une quelconque des revendications 1 à 5, dans lequel l’unité de commande (17) comprend une base de données d’utilisateurs (200) qui mémorise, pour chaque utilisateur, le degré d’anxiété et une valeur de réglage pour réduire le degré d’anxiété.

7. Appareil d’aide au transfert selon la revendication 6, dans lequel la valeur de réglage comprend une limite de vitesse qui est une limite supérieure d’une vitesse d’entraînement de l’unité d’entraînement et fixée en correspondance avec le degré d’anxiété.

8. Appareil d’aide au transfert selon l’une quelconque des revendications 1 à 7, dans lequel l’unité de commande (17) comprend une unité d’accumulation de données (300) qui accumule, pour chaque utilisateur, des données lorsque l’appareil d’aide au transfert est utilisé.

9. Appareil d’aide au transfert selon la revendication 8, dans lequel les données accumulées comprennent, pour chaque utilisateur, une relation entre le degré d’anxiété et la vitesse d’entraînement de l’unité d’entraînement et une relation entre le degré d’anxiété et une position du dispositif de maintien de corps.

10. Appareil d’aide au transfert selon la revendication 1 ou 2, dans lequel l’unité de commande (17) fixe un gain de rétroaction qui réduit à un minimum une fonction d’évaluation qui est basée sur un degré d’anxiété de la personne recevant des soins et une position et une vitesse du dispositif de maintien de corps, et utilise le gain de rétroaction fixé dans une boucle de rétroaction de position, de vitesse, ou d’accélération.

11. Appareil d’aide au transfert selon la revendication 1 ou 2, comprenant en outre une unité de sortie externe (500) qui délivre un signal de représentation d’anxiété qui augmente alors que le sentiment d’anxiété de la personne recevant des soins augmente, dans lequel l’unité de commande (17) génère le signal de représentation d’anxiété et délivre le signal à l’unité de sortie externe pour représenter le sentiment d’anxiété pour un opérateur.

12. Appareil d’aide au transfert selon la revendication 11, dans lequel l’unité de sortie externe (500) comprend un haut-parleur ou un vibreur attaché à l’unité d’opérations et transmet le signal de représentation d’anxiété à un opérateur par un son ou des vibrations.

13. Appareil d’aide au transfert qui aide au transfert d’une personne recevant des soins, comprenant :

une unité de chariot mobile (1) ;
une unité de bras (2) qui est attachée à l’unité de chariot et qui tourne dans un plan horizontal et incliné ;
un dispositif de maintien de corps (3) qui est attaché à l’unité de bras ;
une unité d’entraînement (61, 62, 63, 64, 65) qui entraîne l’unité de chariot et l’unité de bras ;
une unité d’opérations (25) dans laquelle une trajectoire du dispositif de maintien de corps est entrée par une
opération manuelle ; et
une unité de commande (17) qui commande l’unité d’entraînement en correspondance avec la trajectoire entrée
par l’unité d’opérations, et qui effectue une commande à rétroaction pour réduire un degré d’anxiété de la
personne recevant des soins en mémorisant à l’avance une plage de trajectoire de soulagement, qui est une
plage de trajectoire du dispositif de maintien de corps dans laquelle la personne recevant des soins a une
sensation de soulagement, en échantillonnant avec un pas d’échantillonnage prédéterminé une trajectoire du
dispositif de maintien de corps qui est entrée par un opérateur par l’intermédiaire de l’unité d’opérations, en
comparant les données de coordonnées échantillonnées sur la trajectoire avec la plage de trajectoire de sou-
lagement, et lorsque les données de coordonnées échantillonnées sont en-dehors de la plage de trajectoire
de soulagement ou lorsqu’un point prédit sur la base des données de coordonnées échantillonnées dans la
plage de trajectoire de soulagement est prédit comme étant en-dehors de la plage de trajectoire de soulagement,
en corrigeant la trajectoire du dispositif de maintien de corps pour qu’elle entre dans la plage de trajectoire de
soulagement.

14. Appareil d’aide au transfert selon la revendication 13, dans lequel
l’unité de commande (17) corrige, lorsque les données de coordonnées échantillonnées sont en-dehors de la plage
de trajectoire de soulagement ou lorsque le point prédit est prédit comme étant en-dehors de la plage de trajectoire
de soulagement, une position d’un point échantillonné immédiatement avant que les données de coordonnées
echantillonnées soient échantillonnées ou que le point prédit soit prédit, ou au moins d’un point échantillonné avant
que les données de coordonnées échantillonnées soient échantillonnées ou que le point prédit soit prédit, et génère
une trajectoire qui est corrigée de sorte qu’un point prédit sur la base de la position échantillonnée corrigée soit
dans la plage de trajectoire de soulagement.

15. Appareil d’aide au transfert qui aide au transfert d’une personne recevant des soins, comprenant :
une unité de chariot mobile (1) ;
one unité de bras (2) qui comprend une extrémité de base attachée à l’unité de chariot et qui tourne dans un
plan horizontal et incliné ;
un dispositif de maintien de corps (3) qui est attaché à l’unité de bras ;
one unité d’entraînement (61, 62, 63, 64, 65) qui entraîne l’unité de chariot et l’unité de bras ;
one unité d’opérations (25) dans laquelle une trajectoire du dispositif de maintien de corps est entrée par une
opération manuelle ; et
une unité de commande (17) qui commande l’unité d’entraînement en correspondance avec la trajectoire entrée
par l’unité d’opérations, et qui effectue une commande à rétroaction pour réduire un degré d’anxiété de la
personne recevant des soins en mémorisant à l’avance une plage de trajectoire de soulagement, qui est une
plage de trajectoire du dispositif de maintien de corps dans laquelle la personne recevant des soins a une
sensation de soulagement, en échantillonnant avec un pas d’échantillonnage prédéterminé une trajectoire du
dispositif de maintien de corps qu’un opérateur entre par l’unité d’opérations, en comparant les données de
 coordonnées échantillonnées sur la trajectoire avec la plage de trajectoire de soulagement, et lorsque les
données de coordonnées échantillonnées sont en-dehors de la plage de trajectoire de soulagement ou lorsqu’un
point prédit sur la base des données de coordonnées échantillonnées dans la plage de trajectoire de soulagement
est prédit comme étant en-dehors de la plage de trajectoire de soulagement, en ordonnant à l’unité d’opérations
de générer une force de réaction dans une direction qui génère une résistance à une opération d’entrée qui
entre la trajectoire qui s’écarte de la plage de trajectoire de soulagement.

16. Appareil d’aide au transfert selon l’une quelconque des revendications 13 à 15, dans lequel :
l’unité de commande (17) échantillonne une trajectoire du dispositif de maintien de corps en calculant de temps
en temps une position du dispositif de maintien de corps sur la base d’une quantité d’entraînement de l’unité
d’entraînement.

17. Appareil d’aide au transfert selon la revendication 13 ou 16, dans lequel :
l’unité de commande (17) comprend une base de données d’utilisateurs qui mémorise, pour chaque utilisateur,
la plage de trajectoire de soulagement.
FIG. 2
FIG. 9
FIG. 12
FIG. 26
REFERENCES CITED IN THE DESCRIPTION

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