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(54) **System and method for rehabilitation**

(57) A system for rehabilitation with a linkage (1) with integrated joints (3) that can be applied to the body of a human being such that the applied linkage (1) is able to follow selected movements of the body wherein an integrated joint (3) has a drive (4) for moving the joint (3) and a position detector (10, 13) for detecting the position of the drive (4) and/or the joint (3), and with a control (14) for triggering a drive (4) and/or for detecting a sequence of movements through evaluating the position of the drive (4) and/or of the joint (3).

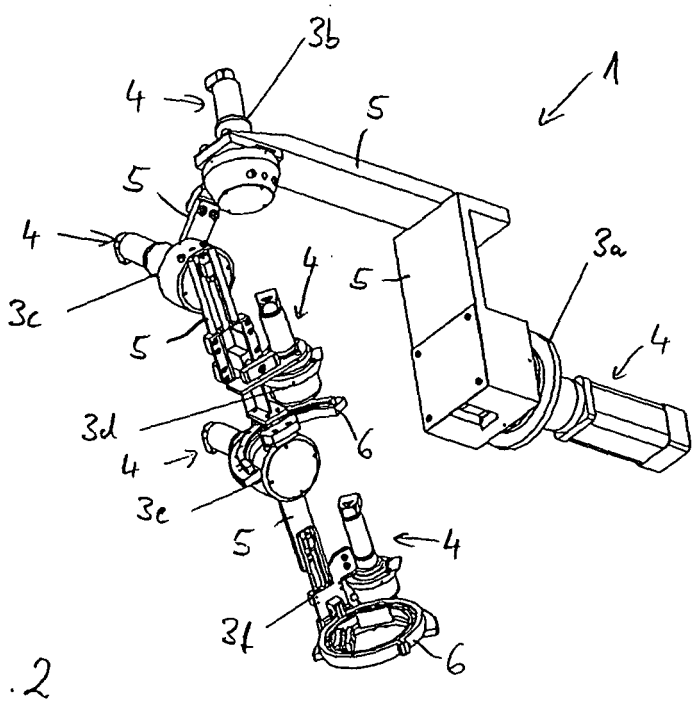

Fig. 2

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Description

[0001] The invention relates to a system for rehabilitation with a linkage that can be applied to the body of a human being and a method for the rehabilitation making use of an appropriate system.

[0002] Rehabilitation through therapeutic exercises is employed among other things with damages of the brain which can be of traumatic origin, have another cause (bleeding, infections or similar) and can cause a comatose state or sensor-motoric disorders which result in a disability. More preferably in the latter case it can be attempted through training of the brain to heal the disability or alleviate its effects. The present invention however is not restricted to this particularly preferred area of application but can always be employed in a supportive manner with any therapeutic exercises.

[0003] Today, such therapeutic exercises are usually conducted by a trained therapist who sets the sequence of movements for the patient to emulate. Alternatively the therapist himself/herself moves certain parts of the body, for example arms or legs of the patient in order to execute the desired sequence of movements with the patient, provided said patient is not independently capable of doing so.

[0004] In addition, training devices that can be employed for rehabilitation are also known which permit a limited number of certain sequences of movements which the patient has to repeatedly execute against an adjustable resistance if applicable.

[0005] These systems have the disadvantage that they usually permit only one or a few selected sequences of movements and provide no possibilities of detection as to the quality in which the set movements are executed.

[0006] The object of the present invention therefore is to propose a system and a method for rehabilitation which make possible the setting of a large number of different sequences of movements and which support and monitor the execution of said sequences of movements.

[0007] According to the invention this object is solved with the characteristics of claims 1 and 9.

[0008] To this end, a linkage with integrated joints can be applied to the body of a human being according to the invention such that the applied linkage is able to re-enact selected movements of the body. An integrated joint has a drive for moving the joint and at least one position detector to sense the position of the drive and/or the joint. In addition, a control for triggering the drives and/or for sensing the sequence of movement by evaluating the position of the drives and/or of the joints is provided in the system. For example the system according to the invention can be a linkage for applying to an arm or a leg which is able to re-enact typical sequences of movements of the arm or leg. In other words, the linkage assumes the function of an external skeleton which makes possible the re-enacting or initiating of the sequence of movements of the human skeleton. Through the design as linkage with integrated joints the system according to the invention is constructed so light-weight compared with most conventional exercise devices that, once applied for example to the arm or leg of a patient, it is not so heavy as to interfere with a natural and free movement. By providing a position detector and a drive for preferably each joint driven or evaluated in a coordinated manner through a common control, the system according to the invention can be used for both monitoring the execution of a set movement as well as for support with the execution of a set movement or a combination of both of these, where a correct movement through the patient is detected and supported and an incorrect movement counteracted if applicable.

[0009] For implementing such a system it has proved to be particularly advantageous if the drive is designed as a rotary drive with a motor for rotating a driveshaft, a motor sensor or encoder for detecting the motor position and preferably a joint sensor or encoder for detecting the joint position. Basically the motor also has a gearing so that the motor can be designed as a geared motor. This has the advantage that the same motor with the same electronics and control can be provided for all joints which are employed and different motion speeds of the joint movement can be realised for example through different gear ratios. This simplifies the construction of the system considerably.

[0010] In order to be able to set a controlled sequence of movements on the one hand and on the other hand detect and support or counteract such movement if applicable through triggering the drive it is particularly advantageous to design the drive of one or each joint as a servo drive where phase-shifting in the drive is possible between a motor movement and a joint movement. Such a servo drive has various advantages. Hence, it makes possible the sequence of movements of the body with an applied linkage relative to the motor position known to a control. This is possible quickly and with only little electronic effort so that the system in an ideal manner can also be operated such that a body movement applied to the linkage from the outside is supported during the sequence of movements through additional following-up of the drives. In addition, the system permits deviations in the sequence of movements in the case of a movement set by the drives which allow drawing conclusions as to whether the patient is capable of following the set sequence of movements or if major resistances occur here. In the latter case such greater resistances can be detected through a comparatively large deviation between the motor position and the joint position so that the sequence of movements can be stopped to avoid injuries.

[0011] A particularly advantageous development of the servo drive provides that the movement of the drive, more preferably the driveshaft, and the movement of the joint are decoupled through a coupling whose coupling effect increases with rising phase shift for example a spring coupling. Through this it is more preferably achieved that with a set movement the force exerted by a patient has to be increased ever more the further he

moves away from the set movement. As a result, an incentive for example to follow the sequence of movements set by a therapist is automatically created.

[0012] In order to implement a set sequence of movements and/or to record a set movement by a body to which the linkage according to the invention is applied, the control can preferably be equipped to set a movement of the joints of the linkage through triggering a drive or several drives and/or to determine a movement of the joints of the linkage (for example through detecting a phase shift between the joint position sensor and the motor position sensor) in deviation from a triggering of the drive and to record said phase shift depending on the operating mode and/or follow-up the drive. Through this it can more preferably be achieved that the drive follows the movement of a joint set from the outside in order to support the movement set from the outside and for example offset the dead weight of the linkage that serves as external skeleton or counteract the actual movement of the linkage, provided another (set) movement objective is to be attained.

[0013] An embodiment of the system which is preferred more preferably in the treatment of neurological damages provides for a device to create a virtual reality with a display and a computation unit with which, taking into account the coordinates of a movement objective for the linkage and the current position of the joints and/or drives of the linkage, a scene supporting the movement objective is presented. With a linkage for an arm this can for example be an object to be gripped arranged in the position of the movement objective. This serves to train a movement coordinated between stimulation of the brain and executions of the locomotor system, which strongly resembles a real situation. By playing concrete objectives the execution of the desired sequence of movements is therefore supported in a mentally active manner.

[0014] According to a simple realisation the device to create a virtual reality can have a three dimensional display each with a separate display for each eye, which for example is integrated in a helmet having the respective display in front of each eye. By taking into account the perspective situation for each eye in the separate display it can be used to actively create the impression of a three-dimensional scene.

[0015] In order to make possible particularly realistic planning of the for example three-dimensional scene the device for creating a virtual reality can take into account movements of the head and/or the eyes relative to the linkage, more preferably if the device has a helmet equipped with suitable sensors.

[0016] The present invention also relates to a method for the rehabilitation making use of the prescribed system where the control has a synchronous operating mode, an asynchronous operating mode and/or a virtual operating mode in order to execute a set sequence of movements of the linkage. The operating modes which are described in more detail in the following can also be combined with one another according to the invention.

[0017] With the synchronous operating mode two linkages can be used according to the invention of which one linkage is a master linkage and one linkage is a slave linkage, wherein the master linkage sets a sequence of movements and the slave linkage executes the set sequence of movement, i.e. re-enacts such sequence of movements. The linkages can be identical linkages or linkages corresponding to one another, for example for a left or a right arm. In this way a therapist for example with the healthy arm or a healthy arm of the patient itself can set the sequence of movements for the disabled arm.

[0018] Here, the control can monitor and display on the master linkage the sequence of movement in the slave linkage and more preferably parameterised deviations from the set movements. The display can for example take place through blocking, accelerating and/or retarding the sequence of movement. Since, according to the invention, the way in which the deviation from the set movement occurs is sensed, it can be displayed through appropriate signals on the master linkage where the deviations occur. This allows the therapist to recognise causes for the deviation and take suitable therapeutic measures.

[0019] With an asynchronous operating mode a sequence of movements can be recorded in a first step with the linkage according to the invention and the recorded sequence of movements executed in a second step, wherein the recorded sequence of movements for this purpose can be stored in the control and transmitted to the linkage for execution.

[0020] With the virtual operating mode, which more preferably can be combined with the asynchronous operating mode, the sequence of movements to be executed can be supported through presentation of a virtual reality on a display in that a scene is created which gives the executing person an incentive, starting from the current position of the linkage, to reach the movement target of the linkage. The movement target in this case can more preferably be an end or target position or a defined intermediate position of a pre-definable sequence of movements.

[0021] Stimulation can be further supported in that the virtually presented scene is continually adjusted to the actual sequence of movements of the linkage.

[0022] In order to be able to configure different therapeutic intensities it is particularly preferentially provided according to the invention that the degree of support of the sequence of movements can be parameterised through the drive. To this end, drive moments to be executed by the drives of the linkage can be set for example. The setting can be in a relative graduation between a maximum drive moment which is selected just so that injuries on the guided body are prevented and a minimum drive moment which just compensates for the dead weight of the linkage, thus not signifying any support in the sequence of movements.

[0023] With the method according to the invention the deviation from the set sequence of movements is pref-

erentially detected by the control with the method according to the invention. This can be achieved in that a connecting straight line between the movement target (end position or intermediate position) and the end point of the linkage, which is to reach the movement target, is determined and, starting from the end point of the linkage, a cone with a settable opening angle around this connecting straight line is defined. The opening angle can then be selected or set such that upon remaining of the end point of the linkage within the cone, reaching of the movement target remains possible even if the end point of the linkage deviates from the connecting straight line without gradients of a directional change having to occur, i.e. no severe directional changes would have to be performed within the course of the sequence of movements to still reach the target. It is then monitored if the end point of the linkage departs from this cone and in this case the control can counteract the movement to support the correct sequence of movements. This check is continually repeated with the movement of the linkage so that in each case the current position of the linkage relative to the end or intermediate target is being monitored.

[0024] To actively support adherence to a set sequence of movements the control, on determining a deviation in the sequence of movements, can trigger the drives such that the correct sequence of movements is supported. If this can no longer be achieved the control can memorise the last correct end position or the position of departure from the prescribed cone, completely release the movement and, if applicable, start supporting the free movement through active tracking of the drives to avoid injuries. In this way it is possible to resume therapy exactly at the aborted point once the linkage, upon a control command by the control, has been returned to this position.

[0025] The system and method according to the invention are described in more detail by means of the example of a linkage that can be applied for a right and a left arm, from which further characteristics, advantages and possible applications of the present invention are obtained. Here, all described and/or depicted characteristics form the object of the present invention, even independent of their combination in the claims or their references.

It shows:

[0026]

Fig. 1 a system according to the invention for rehabilitation for the right and left arm of a patient;

Fig. 2 a linkage designed as an external arm skeleton according to Fig. 1 in detail view;

Fig. 3 a drive of the linkage according to the invention according to Fig. 2;

Fig. 4 a schematic diagram of the components of the system for rehabilitation according to the invention;

Fig. 5 a signal flow-chart for carrying out a method for the rehabilitation according to the invention in an asynchronous operating mode;

Fig. 6 a signal flow chart for carrying out a method for rehabilitation according to the invention in a synchronous operating mode and

Fig. 7 a signal flow-chart for carrying out a method for rehabilitation according to the invention in a virtual operating mode.

[0027] Fig. 1 shows a linkage 1 belonging to a system for rehabilitation which is designed as external skeleton for a right or a left arm 2 of a body. In Fig. 1 the linkage 1 is shown in a state applied to the arm 2 of a human being. The linkage 1 has integrated joints 3 wherein a drive 4 for moving the joint 3 is assigned to each integrated joint 3. The linkage 1 with the joints 3 and the respective assigned drive 4 is described in more detail in the following, making reference to Fig. 2 and 3. It is emphasised that the linkage 1 designed as external arm skeleton merely constitutes an embodiment of the invention to which the invention however is not restricted. In principle, corresponding linkages 1 are conceivable in the same manner of operation and a suitably adjusted realisation also for application to other body parts, more preferably arms, trunk, head or such like.

[0028] The linkage 1 presented in three-dimensional view in a design drawing in Fig. 2 has a total of six joints 3a to 3f and thus makes possible six degrees of freedom of movements. The different joints 3 are connected with one another via suitably shaped and connected linkage parts 5 so that they make possible applying the linkage 1 to the arm 2 of a human being. In addition, each joint 3 is provided with a drive 4 which is described in more detail later on, making reference to Fig. 3.

[0029] The joint 3a is designed as a hinge joint in order to re-enact bending of the arm in the shoulder. With the joint 3b, likewise designed as hinge joint, rotation of the arm about its longitudinal axis of the upper arm can be simulated. The joint 3c designed as additional hinge joint performs a movement for lifting the arm to the front or to the back wherein the joint designed as a linear sliding joint 3d re-enacts the longitudinal offset up to the elbow. The hinge joint 3e is responsible for re-enacting a bending movement of the elbow, wherein the linear sliding joint 3f in turn re-enacts the longitudinal offset of the linkage 1 up to the wrist.

[0030] To fix the linkage 1 to the arm of the patient a collar 6 enclosing the wrist is arranged in the region of the wrist and, in the region of the elbow, a semicircular collar 6 is arranged, which if applicable can be fixed to the elbow with a band which is not shown.

[0031] Each joint 3a to 3f is assigned a separate drive

4 which, as is evident from Fig. 3, has an electric motor 7 which is connected with a gearing 8 and via the gearing 8 drives a drive shaft 9 to execute the desired movement (rotation or translation). To detect the position of the drive 4 a motor position detector 10 is provided.

[0032] Based on the design of the drive 4 as geared motor, movement of the joint 3 connected with the drive 4 is only possible if the motor 7 is triggered if the drive shaft 9 were directly connected with the joint 3. However, since it is desired that the linkage 1 can also be moved through a movement of the arm without the movement being initiated by the drive 4, a coupling 11 designed as actuator coupling is provided to connect the drive shaft 9 with the joint 3 which, in the drive 4, enables a phase shift of a motor movement and a joint movement. Here it is provided that the coupling effect of the coupling 11 increases with rising phase shift between the position of the drive shaft 9 and the position of the joint 3, for the purpose of which a spring 12 loaded in accordance with the phase shift is provided in the coupling 11. To detect the phase shift between the drive 4 or its drive shaft 9 and the joint 3 a joint position detector 13 is provided in the drive 4 on the joint 3 which determines the joint position. From the difference of the joint φ_V and the motor position φ_M it is then possible to determine the phase shift $\Delta\varphi$, which indicates a self-movement of the joint 3 and thus the linkage 1 relative to the drive 4.

[0033] The positions of the drive 4 and the joint 3 determined through the position detectors 10, 13 are monitored in a control 14 for example as phase shift $\Delta\varphi$, which coordinates all functions of the system 15 for rehabilitation. When the phase shift $\Delta\varphi$ detected in the control 14 exceeds a set more preferably configurable threshold value, the drive 4 assigned to this phase shift $\Delta\varphi$ can be activated in order to follow-up the drive shaft 9 such that the phase shift between the drive 4 and the joint 3 disappears and no additional force against the linkage 1 has to be expended by the person to whose arm the linkage 1 is applied in order to hold the arm position.

[0034] This and additional functions are executed by the central control 14 of the system 15 for rehabilitation shown in Fig. 3 which, for this purpose, is connected to a triggering unit 16 which in each case is connected with the linkage 1 and the drives 4 located therein. The triggering unit 16 itself is preferably constructed in a modular manner from several parallel computers so that adequate computation power is available to make possible a real time activation of all drives 4 in the linkage 1 and to read out the read-out position data of the motor position detector 10 and the joint position detector 13. Here, the triggering unit 16 can preferably already calculate possible phase shifts $\Delta\varphi$, passing these on to the central control. Obviously it is also possible to set up the control 14 to calculate a phase shift $\Delta\varphi$. The system 15 additionally has a unit 7 connected to the control 14 to create a virtual reality which will be described in more detail later on.

[0035] In addition, the control 14 is connected with a data base unit 18 known per se in which both data relevant for triggering the linkage 1 as well as patient-related therapy data and such like can be stored, which can be suitably input, processed and retrieved through an administrative program integrated in the control 14. It is also possible to detect the therapy process over several sittings and the sequence of movements of a therapy session by means of the position detectors 10, 13, to evaluate these in the control 14 and to file these as history in the data base or storage unit 18 so that a therapist has access to old therapy data for comparison of therapy progress or such like. Set sequences of movements, which are to be executed by the linkage 1, can also be filed in form of suitable control files. For operation, the control 14 has an operating unit 19. Thus, the system 15 constitutes a comprehensive system for rehabilitation which, in addition to the active execution of therapeutical exercises by means of a linkage 1, also makes possible the administration, archiving and evaluation of the therapies for one or several patients.

[0036] However, the following description is concentrated on the operation of the linkage 1 in different operating modes which are explained in more detail by means of Fig. 5 to 7. Nevertheless, the overall system 15 with all its functions presented before is the object of the present invention.

[0037] A method for rehabilitation with the system 15 described above in an asynchronous operating mode is described with regard to the flow diagram shown in Fig. 5.

[0038] A predefined exercise is executed in the asynchronous operating mode through the linkage 1 applied to the arm 2 of a patient in that the drives 4 of the linkage 1 move the joints 3 in accordance with a set movement schedule to execute a movement of the arm 2 of the patient. To set the sequence of movements the linkage 1 is initially put in a recording mode in order to record a sequence of movements in a first step with the linkage 1. To this end, the linkage 1 can be applied to the patient who performs a sequence of movements in accordance with the settings of the therapist. Alternatively, the therapist can put on the linkage 1 and record the desired sequence of movements. This recorded sequence of movements is processed by the control 14 and stored for example as file in the data base unit 18, from where the file can be loaded back into the control 14 at any time in order to execute the sequence of movements as part of the therapy.

[0039] At the start of recording the linkage 1 is in a reset position in which it is put in recording mode by pressing a recording button (not shown). In order to set the starting position of the sequence of movements the switch is pressed and held in the reset position of the linkage 1 until the linkage 1 is guided to the desired starting position for the sequence of movements. During this movement, each drive 4 passes the recorded joint positions φ_V and motor positions φ_M on to the triggering unit 16 which processes said positions and determines the current linkage position as a function of time. Since the movement is not initiated by the drives 4 a phase shift

$\Delta\varphi$ occurs between the joint positions φ_V and the motor position φ_M which the triggering unit 16 as part of the control 14 uses to send a movement command B ($\Delta\varphi$) dependent on the phase shift $\Delta\varphi$ to the triggering device 20, which then passes a control command S on to the respective drives 4 to actuate the electric motors 7. This means that the linkage 1 through the control 14 or the triggering unit 16 is made to follow the movement set by the arm 2 to achieve a phase shift of $\Delta\varphi = 0$.

[0040] Once the starting position has been reached the switch, which is not shown, is released and recording of the sequence of movements commences wherein the linkage 1 is made to follow the movement of the arm 2 in the manner described above. As soon as the end position of the sequence of movements is reached, the switch is actuated once more to indicate the end of the sequence of movements. Subsequent to this, the triggering unit 16 returns the linkage 1 to the reset position in which the linkage 1 can be removed from the arm 2. The recording function of the linkage 1 is then deactivated and the set sequence of movements is stored.

[0041] When the exercise is to be performed with the recorded sequence of movements a corresponding data file is loaded from the data base 18 into the control unit 14. The set sequence of movements ψ is passed on to the respective triggering unit 16 which then issues a movement command to the triggering device 20 as a function of the stored sequence of movements ψ as B (ψ), which subsequently generates the control command S for the motor 7 of the drive.

[0042] During the execution of the exercise it is possible to change the execution speed via the control 14. The movements are always executed with exactly the speed with which they were recorded. This sequence of movements however can be optionally accelerated or retarded by specifying a percentage deviation.

[0043] It is further possible to set the degree of difficulty of the exercise in the control 14. This is performed by selecting the degree of support of the movement through the motor drive 4. Such a value can be specified in percent, for example in stages relative to the maximum torque with which the linkage 1 is supported at each joint 3, if the patient does not at all contribute to the desired sequence of movements in order to guide the arm of the patient. As a lower limit of adjustability a minimum torque can be selected which does not provide any active movement support but is merely sufficient to support the dead weight of the linkage so as not to render the movement of the patient more difficult through the dead weight of the linkage. Between these two values of a minimum and a maximum torque, support can be selected freely or in set stages.

[0044] Even during the execution of the exercise the joint positions φ_V and the motor positions φ_M are detected by the position detectors 10, 13 in the drives 4 and transmitted to the triggering unit 16 which determines the phase shift $\Delta\varphi$ for each individual drive. These phase shifts $\Delta\varphi$ are then transmitted to the control 14 for each drive 4 which is therefore able to check the quality of the execution of the sequence of movements through the patient in that it monitors and evaluates the phase shifts $\Delta\varphi$ of the various drives 4. Because of the servo drives 4 and the parallel signal processing in several triggering units 16 this is almost possible in real time.

[0045] The control 14 detects movements for example spastic movements or an accelerated sequence of movements deviating from the set sequence of movements for example through the exceeding of certain thresholds which can also be individually defined and parameterised. Once these thresholds are exceeded the control then sets that the triggering unit 16 is to follow the movements of the patient by adjusting the phase shift $\Delta\varphi$ with the movement command B(ψ) to avoid injuries. At the same time the last regular position of the linkage 1 within the scope of the movement command and the deviating movement is recorded until stoppage of the uncoordinated or incorrect movements occurs. The control 14 then sets reverse operation of the movement of the linkage which more preferably is executed with the maximum support. As soon as the starting point of the uncoordinated movement is reached, the mode that executes the set sequence of movements within the scope of an exercise is switched on again.

[0046] In the synchronous operating mode illustrated in Fig 6 a second linkage 1 is provided instead of a prior recording of the sequence of movements which in the following is named master linkage. The master linkage 1 is either provided identically or in mirror-image to the linkage 1 which is to execute the therapy and is subsequently named slave linkage. The master linkage for example is situated on a healthy arm of the patient or therapist while the slave linkage is located on the arm of the patient to be treated.

[0047] Once the master and slave linkage have been applied, both are in their reset position. By pressing a switch that is not shown on the master linkage, movement synchronisation of the two linkages 1 is started. Upon releasing of this switch and on re-actuating said switch the synchronous actuating process is stopped and both linkages are moved back to their reset position. A switch that might be provided on the slave linkage is deactivated in synchronous operating mode.

[0048] Through the motor position detector 10 and the joint position detector 13, the joint positions φ_V and the motor positions φ_M of all drives 4 of the master linkage 1 involved are detected in the already described manner and passed on to the triggering units 16 which determine the phase shifts $\Delta\varphi$ from these. The phase shifts $\Delta\varphi$ of each drive 4 are passed on to the control 14 which generates a sequence of movements ψ from these. Since preferentially a separate triggering unit 16 is provided for each drive, the data of the various drives 4 is transmitted to the control 14 almost at the same time, which is therefore able to create the sequence of movements ψ in real time, passing it on to the triggering units 16 of the slave linkage 1. These create a movement command B(ψ) as

a function of the set sequence of movements ψ which is passed on to the respectively assigned triggering device 20 where it is converted into a control command S to the drives 4 of the slave linkage 1 so that the movements can be re-enacted almost in real time.

[0049] As previously described in connection with the asynchronous operating mode, the degree of support can also be adjusted in this case.

[0050] During the execution of the movement through the slave linkage 1 the joint position φ_V and the motor position φ_M are detected by the position detectors 10, 13 on each drive 4 of the slave linkage and passed on to the respective triggering unit 16 of the slave linkage 1, which determines a phase shift $\Delta\varphi$ from these. This shows how well the patient follows the said movement. This is monitored by the control 14 in the manner described, which in the case of greater deviations can issue a movement command B to the triggering unit 16 of the master linkage 1 which in the known manner is passed on to the master linkage 1 via the triggering device 20 so that for example the therapist notices when the patient fails to optimally follow the movements preset by said therapist. Here, the exact movement deviation of the patient is advantageously re-enacted.

[0051] Making reference to Fig. 7 a particularly preferred embodiment of the invention is described in the following where the method for rehabilitation is executed in a virtual operating mode. To this end, the control 14 which otherwise cooperates with the linkage 1 similar to the embodiments described before, is additionally connected with a unit 17 for creating a virtual reality running a program for creating images as a function of a sequence of movement ψ set by the control 14.

[0052] Here, the unit 17 for creating a virtual reality preferably creates two image commands V which are passed on to monitors arranged in front of the eyes of the patient which are arranged in a helmet 21 for the playing of the virtual reality. The helmet 21 is equipped with sensors 22 which make possible the detection of the position of the helmet 21 and/or the direction of vision of the eyes within the helmet, which are passed back as sensor data D to the unit for creating the virtual reality 17, so that, in creating the virtual reality, it can be used to react to a corresponding movement behaviour of the patient.

[0053] Depending on the set sequence of movements ψ a scene is then played to the patient in the helmet 21 for example in which the patient is to grip an object which is exactly located at the end point of the set sequence of movements ψ. In the already described manner the sequence of movements of the linkage 1 is then monitored and/or supported.

[0054] In order to decide if the movement of the patient is in agreement with the said virtual reality it is possible for example based on the actual position of the end of the linkage 1 to decide if the movement is directed in the direction of the set intermediate or end position of the sequence of movements ψ or not. To this end, starting from the actual position of the linkage 1, a linear connection to the next target point (intermediate or end position) can be defined and starting from the linkage 1 a cone with a certain opening angle can be set which is dimensioned so that upon continuation of the movement the target point can be reached without abrupt directional change, which can be configured by means of threshold values.

[0055] As soon as the linkage 1 departs from the interior of this cone corrective intervention is possible. This procedure is continually repeated so that in each case, based on the current position of the linkage 1, a topical basis for decision making is available.

[0056] The provision of a virtual reality is more preferably suitable in the treatment of neurological illnesses since in this case the nervous stimulations of a real world are simulated in the brain and the typical movement reactions in this regard can be expertly trained.

List of reference numbers:

[0057]

1	Linkage as external arm skeleton
2	Arm of a human being
3	Joint
4	Drive
5	Linkage parts
6	Collar
7	Electric motor
8	Gearing
9	Drive shaft
10	Motor position detector
11	Coupling
12	Spring
13	Joint position detector
14	Control
15	System for rehabilitation
16	Triggering unit
17	Unit for creating a virtual reality
18	Data base unit
19	Operating unit
20	Triggering device
21	Helmet
φ_V	Joint position
φ_M	Motor position
$\Delta\varphi$	Phase shift
ψ	Sequence of movements
B	Movement command
S	Control command
V	Image command
D	Sensor data

Claims

1. A system for rehabilitation with a linkage (1) with in-

tegrated joints (3) that can be applied to the body of a human being such that the applied linkage (1) is able to follow selected movements of the body wherein an integrated joint (3) has a drive (4) for moving the joint (3) and a position detector (10, 13) for detecting the position of the drive (4) and/or the joint (3), and with a control (14) for triggering a drive (4) and/or for detecting a sequence of movements through evaluating the position of the drive (4) and/or of the joint (3).

2. A system according to claim 1, **characterized in that** the drive (4) is designed as a rotary drive with a motor (7) for rotating a drive shaft (9), a motor sensor (10) for detecting the motor position and/or a joint sensor (13) for detecting the joint position.

3. The system according to claim 1 or 2, **characterized in that** the drive (4) is designed as servo drive where a phase shift in the drive (4) between a motor movement and a joint movement is possible.

4. The system according to claim 3, **characterized in that** the movement of the drive (4) and the movement of the joint (3) are decoupled through a coupling (11) whose coupling effect increases with rising phase shift.

5. The system according to any one of the preceding claims, **characterized in that** the control (14) sets a movement of the joints (3) of the linkage (1) through triggering a drive (4) or several drives (4) and/or determines and records a movement of the joints (3) of the linkage (1) in deviation from a triggering of the drive (4) and/or follows-up the drive (4).

6. The system according to any one of the preceding claims, **characterized through** a device for creating a virtual reality with a display and a computation unit (17) in which, taking into account the coordinates of a movement target for the linkage (1) and the current position of the linkage (1), a scene supporting the movement target is displayed.

7. The system according to claim 6, **characterized in that** the device for creating a virtual reality has a three-dimensional display with a separate display for each eye.

8. The system according to claim 6 or 7, **characterized in that** the device for creating a virtual reality takes into account movements of the head and/or the eyes relative to the linkage (1).

9. The method for rehabilitation with a system according to any one of the claims 1 to 8, **characterized in that** the control (14) has a synchronous operating mode, an asynchronous operating mode and/or a virtual operating mode in order to execute a set sequence of movements of the linkage (1).

10. The method according to claim 9, **characterized in that** with the synchronous operating mode two linkages (1) are used of which one linkage (1) is a master linkage and one linkage (1) is a slave linkage, wherein the master linkage (1) sets a sequence of movements and the slave linkage (1) executes the set sequence of movements.

11. The method according to claim 10, **characterized in that** the control (14) monitors the sequence of movements in the slave linkage (1) and, upon deviations from the set movements, indicates set sequence of movements on the master linkage (1).

12. The method according to any one of the claims 9 to 11, **characterized in that** with the asynchronous operating mode in a first step a sequence of movement is recorded with the linkage (1) and the recorded sequence of movement is executed in a second step.

13. The method according to any one of the claims 9 to 12, **characterized in that** with the virtual operating mode the sequence of movements to be executed is supported through presentation of a virtual reality on a display **in that** a scene is created which gives the executing person an incentive, based on the current position of the linkage (1), to reach the movement target of the linkage (1).

14. The method according to claim 13, **characterized in that** the virtually presented scene is adapted to the actual sequence of movements of the linkage (1).

15. The method according to any one of the claims 9 to 13, **characterized in that** the degree of support of the sequence of movements by the drive (4) can be parameterised.

16. The method according to any one of the claims 9 to 15, **characterized in that** the deviation of the sequence of movements from the set sequence of movements is detected.

17. The method according to claim 16, **characterized in that** the control (14) upon detection of a deviation in the sequence of movements triggers the drives (4) such that the correct sequence of movements is supported.

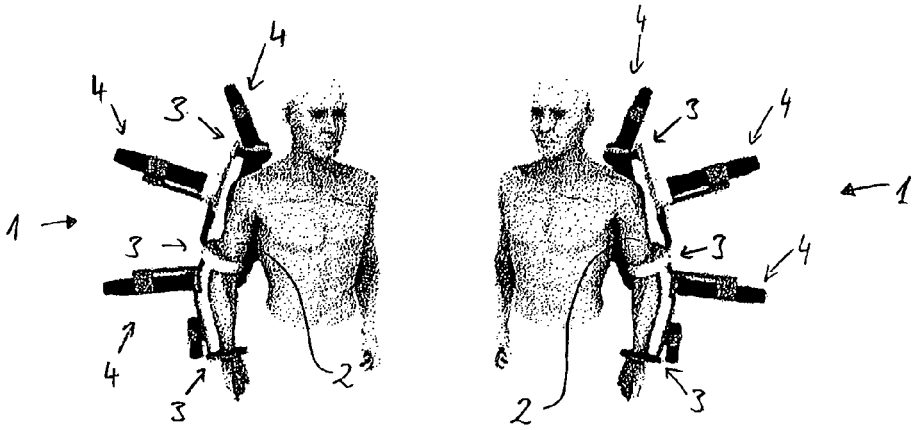

Fig. 1

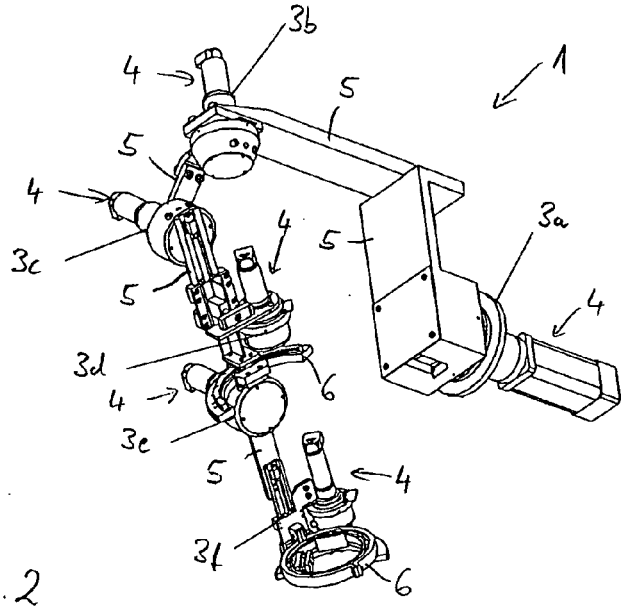

Fig. 2

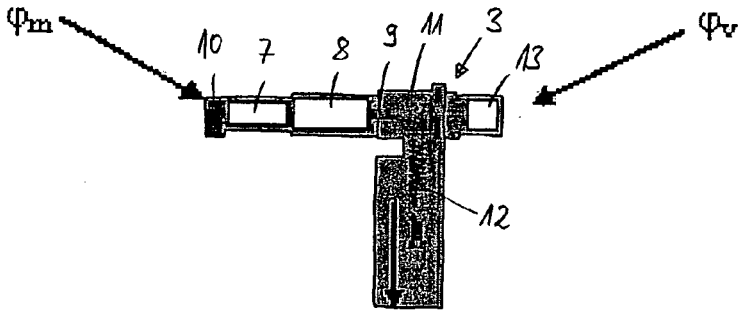

Fig. 3

$$\Delta\varphi = \varphi_v - \varphi_m$$

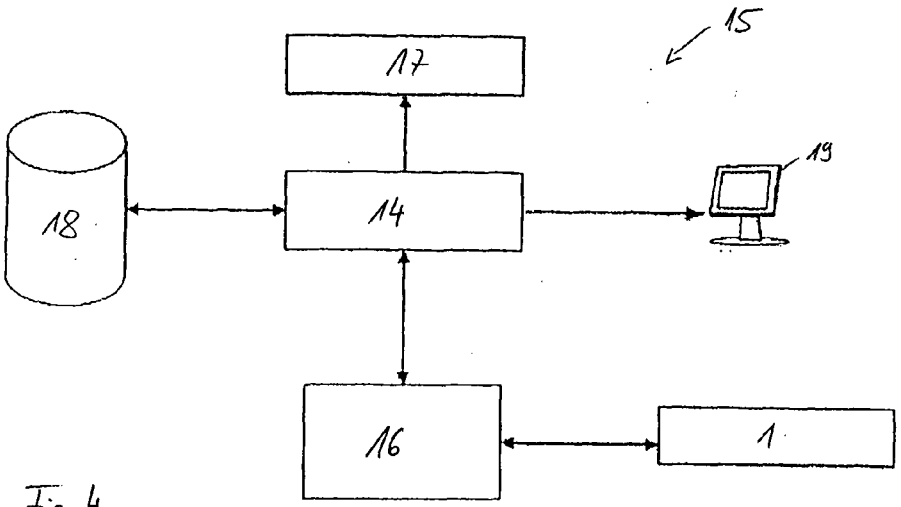

Fig. 4

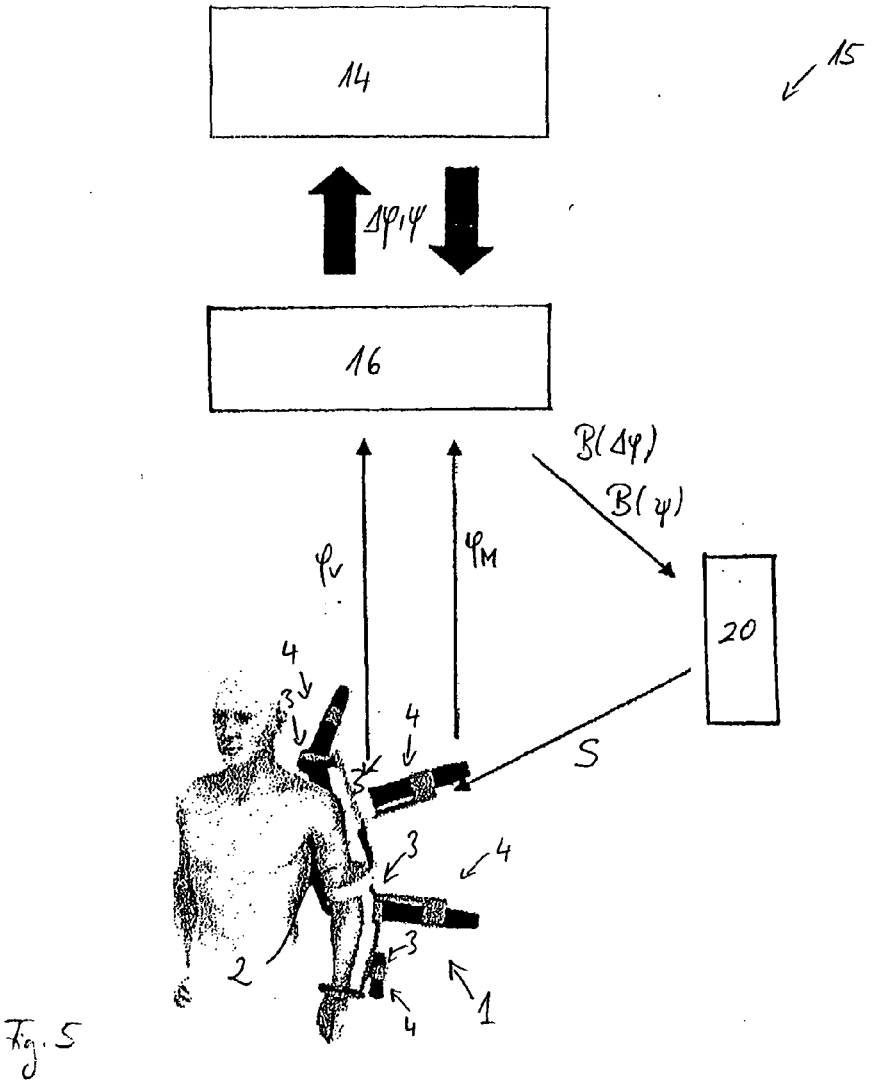

Fig. 5

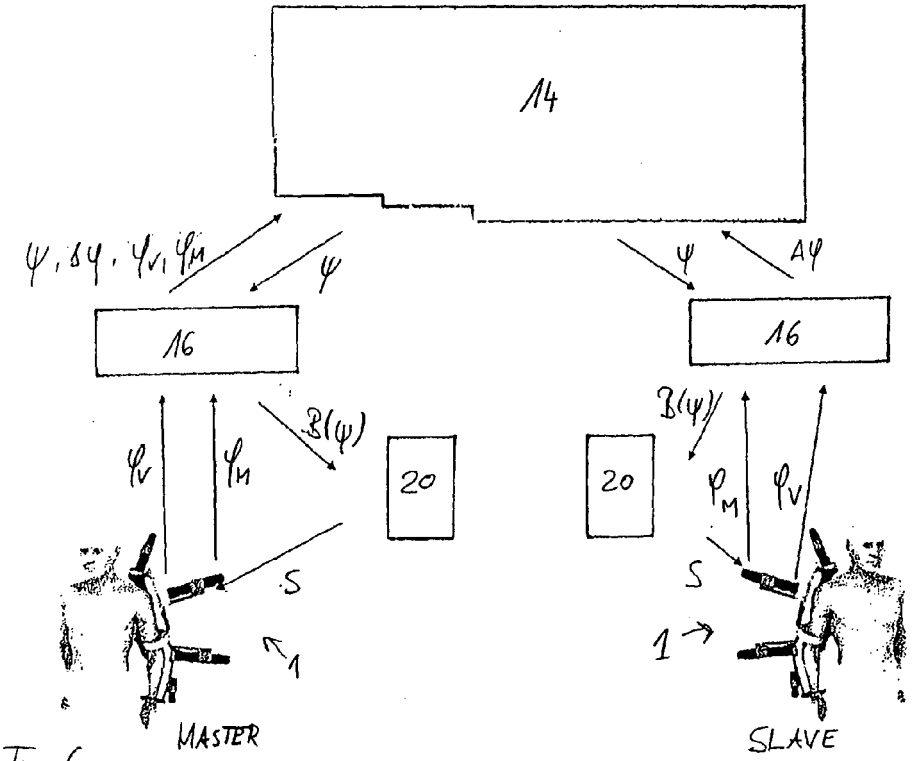
14
ψ, Δψ, φV, φM
ψ
ψ
Δψ
16
16
B(ψ)
B(ψ)
φV
φM
20
20
φM
φV
S
S
1
1
MASTER
SLAVE

Fig. 6

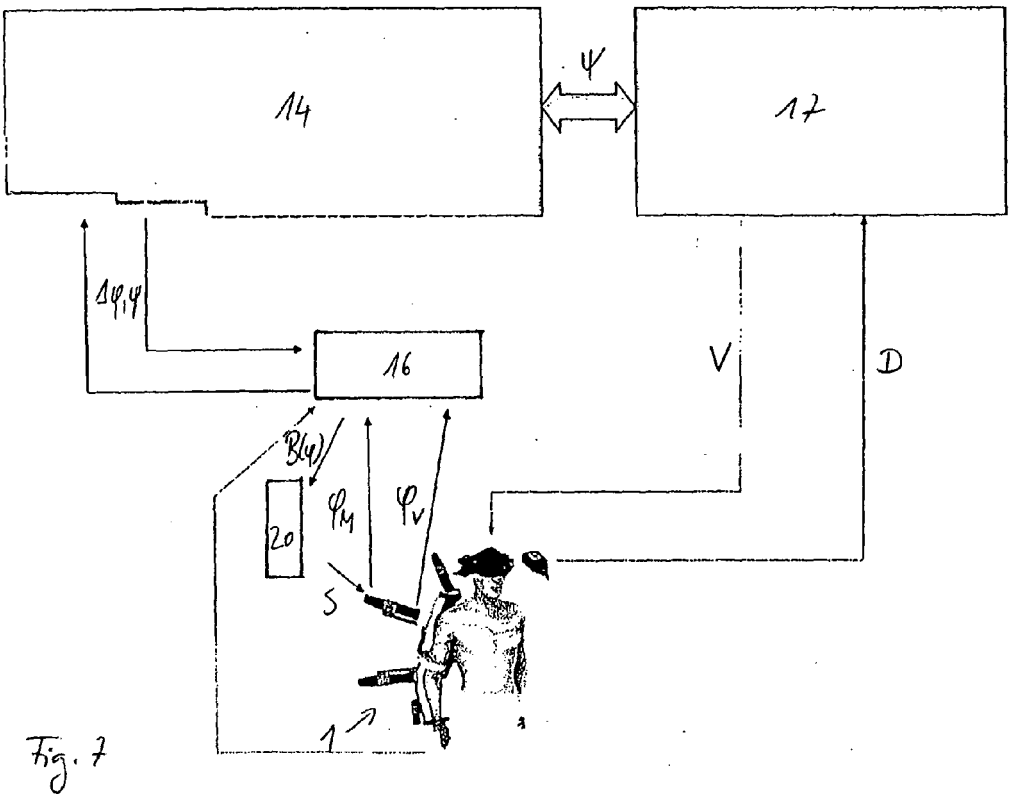
14
ψ
17
Δφ,ψ
16
V
D
B(ψ)
20
φM
φV
S
1

Fig. 7

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PARTIAL EUROPEAN SEARCH REPORT

Application Number EP 08 01 4972

which under Rule 63 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

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INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

Place of search	Date of completion of the search	Examiner
The Hague	12 February 2009	Knoflacher, Nikolaus

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X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
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2

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PARTIAL EUROPEAN SEARCH REPORT

Application Number
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INCOMPLETE SEARCH SHEET C

Application Number
EP 08 01 4972

Claim(s) not searched:
9-17

Reason for the limitation of the search (non-patentable invention(s)):

Article 53 (c) EPC - Method for treatment of the human or animal body by therapy

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 01 4972

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