(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 326 603 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
12.02.2020 Bulletin 2020/07

(51) Int Cl.:
A61H 3/00 *(2006.01)* *A61H 3/04* *(2006.01)*

(21) Application number: **16002500.3**

(22) Date of filing: **24.11.2016**

(54) **HYBRID USER-INTENTION-ASSESSMENT BASED CONTROL SYSTEM FOR A SMART WALKING ASSIST SYSTEM**

HYBRIDES BENUTZERABSICHTSBEURTEILUNGSSTEUERUNGSSYSTEM FÜR EIN INTELLIGENTES GEHASSISTENZSYSTEM

SYSTÈME DE COMMANDE HYBRIDE À BASE D'ÉVALUATION D'INTENTION D'UTILISATEUR POUR SYSTÈME INTELLIGENT D'AIDE À LA MARCHE

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(43) Date of publication of application:
30.05.2018 Bulletin 2018/22

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EP 3 326 603 B1

Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

[0001] Walk rehabilitation is a multi-step process that is aimed to return the freedom of motion to the patient. It starts with intense therapy of the muscular system and proceeds with the supervised static and dynamic balance training.

[0002] The dynamic balance training is typically performed in presence of at least two expert therapist that manually assist the subject to walk and maintain the balance at the same time. Several technical solutions have been proposed to relieve the therapists from this physically intensive engagement.

[0003] Document DE102008029564 A1 discloses a device for muscle training. It has a carrier platform that has a mobile module attached at a driving chassis by the driving device. At one end of the retaining arm a supporting mechanism is arranged to support the user, whereas the other end of the retaining arm is connected to the carrier platform by means of two pivotal connections arranged such that the pivot axes are arranged perpendicular to each other. The retaining arm can thus be inclined in forward/backward direction as well as in left/right direction. The device generates control signals based on a deflection of the retaining arm from its reference position to control the speed of the carrier platform.

[0004] This invention relates to the Gait Balance Trainer device, a therapist controlled motor driven device that is used for balance training during walking. Two independent motorized wheels on each side of the platform's base frame are used for powered actuation of the device in terms of linear (forward / backward) and rotational movement, allowing the device to move in straight lines or turn at different turning radii.

[0005] The patient that uses the device is embraced around pelvis with the appropriate harness, which is coupled to two vertical rods/struts. These struts are mounted to the base frame of the device using adjustable helical springs, which allow the therapist to select the amount of physical support of the patient during training by changing the spring's compliance.

[0006] The framework ensures natural pelvic movement and fail-safe training conditions for the patient. The patient is given ability to lean forward, backward and sideways and/or rotate in the pelvic region. This movement provokes the helical springs to bend from vertical position, producing a stabilizing force on the patient.

[0007] Without the claimed invention, the therapist controls the device during training using a remote control, manually setting the speed at which the device moves forward/backwards and rotates.

[0008] Although heightened focus of the therapist to the patient's progress is required at initial stages of the training, the rehabilitation process is long and does not require a patient to be constantly monitored and device's motion controlled by the therapist. A control system was therefore designed to relieve the therapist of the constant and direct control of the platform and allow the platform to actively follow the patient's motion.

SUMMARY OF THE INVENTION

[0009] The invention is in relation to the design, inclusion and implementation of the control system for walking assist and rehabilitation platform. The presented control system produces the control signals for the platform actuators by joining the information on relative user position in regards to the platform, forces the user is exerting to platform, current operating mode of the system, control strategy, platform's position in the environment, position of the obstacles in the environment and/or therapist commands.

[0010] The aim of the control system is to relieve the therapist of the constant and direct control of the platform and allow a controlled partial or full handover of the control of the platform to a user (a patient that is using the device).

[0011] The relative user's position in regards to the platform is determined by observing the deflection of the user-supporting struts. In case of using the harness that allows the patient to move relatively freely in the horizontal plane and rotate in pelvic region around the vertical axis, the struts deflect out of phase with the rotation of the user's pelvis and in-phase with forward/backward or lateral motion.

[0012] The deflection angles of the struts can therefore be decomposed into three separate states, describing user's relative rotation around the vertical axis and relative position with two planar coordinates.

[0013] The measured user's position is then converted into the estimate of the user's intentions of motion, which is then used to construct the control signals for the platform drivetrain.

[0014] The central control sub-system receives input from the user-intention-determination sub-system, user interface sub-system, therapist user-interface sub-system and optionally from navigation sub-system, which determines the position of the platform and potential obstacles in the environment. Final commands to the system's drivetrain are generated by combining all those inputs according to the selected operational mode (e.g. full user control, full therapist control, adaptive user control etc.).

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The object of the invention will be explained in the following on the basis of the accompanying drawings. The list of drawings:

Fig. 1: Illustration of a user and the walking assist system, that the claimed control system can be applied to.

Fig. 2: Illustration of the measured angles, viewed from the side and back.

Fig. 3: Illustration of basic strut perturbation patterns with indicated user intention, as viewed from the top.

Fig. 4: Control system sub-systems.

Fig. 5: Illustration of additional strut perturbation patterns that indicate side-to-side user motion.

Fig. 6: Block diagram of the claimed control algorithm.

DETAILED DESCRIPTION OF THE INVENTION

[0016] The concept of the invention is a functional upgrade in terms of a central control system of (but not limited to) an existing rehabilitation platform Gait Balance Trainer (Patent application US2014/0179493 A1) for the purpose of increasing the platform's autonomy either by executing a controlled handover to a user, therapist, internal navigation system or a combination of those.

[0017] The claimed control system is organized into logical groups or sub-systems that are illustrated in Fig. 4. The *Central control sub-system* **30** functions as a hub for all control-related information and does central processing of the data. It is interconnected with other sub-systems, the *User intention determination sub-system* **29,** that handles the determination and interpretation of user intentions, as will be described later on, the *User interface sub-system* **28,** which is designed for communication with the user of the device 1, the *Therapist user-interface sub-system* **32,** which is designed for communication with the therapist, that is in charge of the rehabilitation process, optional *Navigation sub-system* **33,** that is determining the relation between the platform, illustrated in Fig. 1, and the environment, while the *Drivetrain unit sub-system* **31** controls the drivetrain units 8 and **9.**

[0018] The platform, that the claimed control system is applied to, is illustrated in Fig. 1. The platform, that can move in world coordinate system **14,** consists of the base frame **13** with two drivetrain units **8** and **9,** that actuate two wheels in contact with the ground, data processing unit **12,** two or more un-actuated wheels **10** and **11,** attachment points **6** and **7** for the user-supporting vertical struts **3** and **5,** user attachment harness **4** and horizontal strut **2.**

[0019] User **1** is strapped to the platform with the help of the attachment harness **4** that together with horizontal strut **2** and vertical struts **3** and **5** allows a freedom of motion in regards to the platform's base frame **13,** while providing the support in the case of the user losing balance and thus preventing the user **1** from falling. The elastic connecting joints **6, 7** between the vertical struts **3, 5** and base frame **13** can have adjustable stiffness, that affects the relation between the exerted force of the user **1** to the harness **4** and the vertical struts **3, 5** deflection from the vertical position, as illustrated in Fig. 2.

[0020] As the user initiates a forward/backwards motion (or motion that is faster or slower than the current velocity of the platform's base frame **13),** the vertical struts **3, 5** are deflected for a certain angle **16** from the neutral position **17** that is proportional to the force. Side motion of the user deflects the vertical struts **3, 5** from neutral vertical position **20** as illustrated by the angle **19** and the rotational motion of the user **1** in the pelvic area around the vertical axis (Patent application WO2014081400 A2) deflects the vertical struts **3, 5** from the vertical position in the opposite directions.

[0021] The deflection of the struts is measured as a difference in orientation of the vertical-struts-fixed coordinate system **15, 18** in regards to the base-frame-fixed coordinate system **21, 22** or/and the world coordinate system **14.**

[0022] Due to the use of the elastic connection between the base frame **13** and the vertical struts **3, 5,** the deflection angles **16, 19** of the vertical struts are proportional to the forces exerted by the user **1** in regards to the platform base frame **13.**

[0023] Five basic motion patterns are observed on the base of deflection (perturbation) of the left **5** and right **3** vertical strut in regards to the base frame **13.** These patterns are illustrated in Fig. 3. In case the user **1** is moving in the same direction and with the same speed as the base frame **13,** there is no deflection of the left **5** and right **3** vertical struts, hence no change in the platforms motion is required, as depicted in **23.** If both left **5** and right **3** vertical struts are deflected in the forward direction, this is interpreted as user intention of accelerating in the forward direction, as depicted in **24.** If both left **5** and right **3** vertical struts are deflected in the backwards direction, this is interpreted as user intention of accelerating in the backward direction, as depicted in **25.** Similarly, the situation with left strut **5** being deflected forwards and right strut **3** being deflected backwards is interpreted as user intention of turning in the clock-wise direction if seen from the top, as depicted in **26.** The opposite situation with left strut **5** being deflected backwards and the right strut **3** being deflected forwards is interpreted as user intention of turning in anti-clock-wise direction, as depicted in **27.**

[0024] There are some additional motion patterns observed from the deflection angles of the vertical struts, that are the result of side-to-side motion of the user **1,** as illustrated in Fig. 5. In this case, both left **5** and right **3** vertical struts are deflected in the same sideways direction. Such motion pattern is optionally used as an additional indication of user intention of walking in diagonal direction and is also used to assess the user's ability to maintain its balance while walking. This assessment is then optionally used by the *Central control sub-system* **30** to select and switch between control strategies.

[0025] The main concept of the claimed control system invention lies in determining the user's intention of moving forward/backward and steering by using strut deflec-

tion angles (which is processed by the *User intention determination sub-system* 29), then producing the appropriate control signals in *Central control sub-system* **30** for the platform drivetrain (handled by the *Drivetrain unit sub-system* **31)** to intuitively follow the user or control the platforms motion via other means (remote control via *Therapist user-interface sub-system* **32,** full automatic navigation or semi-automatic navigation with the use of the *Navigation sub-system* **33** etc.).

[0026] The logic behind the control process that allows the user to control the platform is illustrated by the block diagram in Fig. 6. The illustrated logic is evaluated periodically as a part of the control loop in the *Central control sub-system* **30.** Evaluation of the control process is started at the entry point **34,** where the signal, that corresponds to the quantified assessment of the user intention, defined as intended lateral and rotational motion, is compared with its deadband specification **35.** If the absolute signal value is less than its specified deadband, the control signal value from previous iteration is decayed using the exponent function in order to obtain the effect of smooth transition between deadband and out-of-deadband situations. If the signal comparison in block **35** results in negative, the direction of the signal (the assessment of the user-intended motion) is compared with the existing direction of platform's motion in block **39.** Namely, if the user commands the motion that is in the opposite direction of the current motion, exponential braking step **40** is executed first to command the platform's motion to a smooth, but actively-executed stop, before accelerating in the requested direction. The exponential braking step **40** uses similar approach as the Decay signal values step **36** with the difference in the fact that the signal decay slope is controlled by the amplitude of the commanded signal. Therefore, bigger signal values result in more aggressive stopping motion, allowing anything from a controlled slow stop with small commanded signal values up to almost abrupt stop, as a result of large commanded signal. On the other hand, a PID controller **37** is used for controlling the motion of the platform while the direction of the commanded signal coincides with the direction of the current platform's motion.

Claims

1. A walking assist system comprising:

- a platform further comprising a U-shaped base frame **(13)** with two motorized wheels driven by drivetrain units **(8, 9)** and with at least two unactuated wheels **(10, 11)** which enable the platform to be moved both linearly and rotationally around a vertical axis;
- a user-supporting system further comprising a pair of vertical struts **(3, 5)** attached by means of elastic connecting joints **(6, 7)** to the base frame **(13)** of the platform, a horizontal strut **(2)** that interconnects the pair of vertical struts **(3, 5)** on the upper end thereof, and a user harness with straps **(4)** attached to the horizontal strut **(2)** by means of which the user is safely strapped-in in order to prevent the user from falling, wherein the elastic connecting joints **(6, 7)** are formed such to allow the pivotal deflection of the struts **(3, 5)** from the neutral vertical position **(17);** and
- a control system;

characterized in that the system further comprises a device for measuring the deflections of the struts **(3, 5)** from the neutral vertical position **(17),** said deflections being proportional to the forces exerted on the struts by the user **(1),**
wherein the control system enables the platform to actively follow the intended motion of the user on the basis of a signal received from the device, and wherein the control system is organized into logical groups or sub-systems as follows:

◦ a central control sub-system **(30)** functioning as a hub for all control-related information and performing central processing of the data;
◦ a user intention determination sub-system **(29)** that handles the determination and interpretation of user intentions,
◦ a user interface sub-system **(28)** designed for communication with the user **(1)** of the system,
◦ a therapist user-interface sub-system **(32)** designed for communication with the therapist who is in charge of the rehabilitation process, and
◦ a drivetrain unit sub-system **(31)** controlling the drivetrain units **(8, 9);**

wherein said central control sub-system **(30)** is interconnected with other mentioned sub-systems **(29, 28, 32, 31),** wherein the user intention determination sub-system **(29)** is designed to control the motion of the platform as follows:

• when there is no deflection of the left **(5)** and right **(3)** vertical, the control system maintains the motion of the platform as it is,
• when both left **(5)** and right **(3)** vertical struts are deflected forwards, the control system responds by accelerating the platform forwards,
• when both left **(5)** and right **(3)** vertical struts are deflected backwards, the control system responds by accelerating the platform backwards,
• when the left strut **(5)** is deflected forwards and the right strut **(3)** is deflected backwards, the control system responds by turning the platform in clock-wise direction if viewed from the top, and
• when the left strut **(5)** is deflected backwards and the right strut **(3)** is deflected forwards, the control system responds by turning the platform

in counter clock-wise direction if viewed from the top.

2. The walking assist system according to claim 1, **characterized in that** the control system is organized into further logical group or sub-system, namely a navigation sub-system **(33)** that determines the relation between the platform and the environment; wherein said central control sub-system **(30)** is interconnected also with the navigation sub-system **(33).**

3. The walking assist system according to claim 1 or 2, **characterized in that** the user interface sub-system **(28)** is used to communicate to the user the state of the system and optionally to allow the user to change the control strategy or to control the system parameters.

4. The walking assist system according to any of the claims 1 to 3, **characterized in that** the therapist user-interface sub-system **(32)** is used to communicate to the therapist the state of the system, the assessment of the user's walking capabilities and to allow the therapist to change the control strategy or to control the system parameters.

5. Control procedure for the system according to any of the previous claims, comprising the following steps:

a) comparison **(35)** of the quantified assessment of the user intention in form of a signal **(34)** with a deadband;
if its absolute value of said signal is less than the specified deadband value, the procedure continuous with step e), otherwise the procedure continues with step b),
b) comparison **(39)** of the direction of the input signal from step a) with the existing direction of the motion of the platform;
if the directions are opposite, the procedure continues with step c), otherwise the procedure continues with step d)
c) exponential braking **(40)** to bring the motion of the platform to a smooth but actively-executed stop, with the signal decay slope controlled by the amplitude of the controlled signal, then the procedure is finished **(38);**
d) controlling **(37)** the motion of the platform by means of a PID controller, then the procedure is finished **(38);**
e) decaying **(36)** signal values, then the procedure is finished **(38).**

Patentansprüche

1. Gehassistenzsystem, umfassend:

- eine Plattform, die des Weiteren einen U-förmigen Basisrahmen (13) mit zwei motorisierten Rädern, die durch Antriebseinheiten (8, 9) angetrieben werden, und mit mindestens zwei nicht-betätigten Rädern (10, 11) umfasst, die ermöglichen, dass die Plattform sowohl linear als auch in Drehrichtung um eine Vertikalachse herum bewegt werden kann;
- ein Benutzerhaltesystem, das des Weiteren ein Paar vertikaler Streben (3, 5), die mittels elastischer Verbindungsgelenke (6, 7) an dem Basisrahmen (13) der Plattform befestigt sind, eine horizontale Strebe (2), welche das Paar der vertikalen Streben (3, 5) an deren oberen Ende verbindet, und ein Benutzergeschirr mit Riemen (4) umfasst, die an der horizontalen Strebe (2) befestigt sind, womit der Benutzer sicher angeschnallt wird, um zu verhindern, dass der Benutzer fällt, wobei die elastischen Verbindungsgelenke (6, 7) so gebildet sind, dass die scharnierartige Ablenkung der Streben (3, 5) aus der neutralen vertikalen Position (17) ermöglicht wird; und
- ein Steuerungssystem;

dadurch gekennzeichnet, dass das System des Weiteren eine Vorrichtung zum Messen der Ablenkungen der Streben (3, 5) aus der neutralen vertikalen Position (17) umfasst, wobei die Ablenkungen proportional zu den Kräften sind, die durch den Benutzer (1) auf die Streben ausgeübt werden,
wobei das Steuerungssystem der Plattform ermöglicht, der beabsichtigten Bewegung des Benutzers auf der Basis eines von der Vorrichtung empfangenen Signals aktiv zu folgen, und wobei das Steuerungssystem wie folgt in logischen Gruppen oder Subsystemen organisiert ist:

◦ ein zentrales Steuerungssubsystem (30), das als Mittelpunkt für alle steuerungsbedingten Informationen fungiert und zentrale Verarbeitung der Daten durchführt; und
◦ ein Benutzerabsichtermittlungssubsystem (29), das die Ermittlung und Interpretation der Absichten des Benutzers handhabt,
◦ ein Benutzerschnittstellensubsystem (28), das zur Kommunikation mit dem Benutzer (1) des Systems vorgesehen ist,
◦ ein Benutzerschnittstellensubsystem für Therapeuten (32), das zur Kommunikation mit dem Therapeuten vorgesehen ist, der für den Rehabilitierungsprozess verantwortlich ist, und
◦ ein Antriebseinheitssubsystem (31), welches die Antriebseinheiten (8, 9) steuert;

wobei das zentrale Steuerungssubsystem (30) mit den anderen genannten Subsystemen (29, 28, 32, 31) verbunden ist, wobei das Benutzerabsichtermittlungssubsystem (29) vorgesehen ist, um die Bewegung der Plattform wie folgt zu steuern:

- wenn keine Ablenkung der linken (5) und rechten (3) Vertikalen vorhanden ist, hält das Steuerungssystem die Bewegung der Plattform so, wie sie ist,
- wenn sowohl die linke (5) als auch die rechte (3) vertikale Strebe vorwärts abgelenkt sind, reagiert das Steuerungssystem, indem die Plattform vorwärts beschleunigt wird,
- wenn sowohl die linke (5) als auch die rechte (3) vertikale Strebe rückwärts abgelenkt sind, reagiert das Steuerungssystem, indem die Plattform rückwärts beschleunigt wird,
- wenn die linke Strebe (5) vorwärts abgelenkt ist und die rechte Strebe (3) rückwärts abgelenkt ist, reagiert das Steuerungssystem, indem die Plattform, von oben gesehen, im Uhrzeigersinn gedreht wird, und
- wenn die linke Strebe (5) rückwärts abgelenkt ist und die rechte Strebe (3) vorwärts abgelenkt ist, reagiert das Steuerungssystem, indem die Plattform, von oben gesehen, gegen den Uhrzeigersinn gedreht wird.

2. Gehassistenzsystem nach Anspruch 1, **dadurch gekennzeichnet, dass** das Steuerungssystem in weitere logische Gruppen oder Subsysteme organisiert ist, nämlich ein Navigationssubsystem (33), das die Beziehung zwischen der Plattform und der Umgebung ermittelt; wobei das zentrale Steuerungssubsystem (30) auch mit dem Navigationssubsystem (33) verbunden ist.

3. Gehassistenzsystem nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** das Benutzerschnittstellensubsystem (28) verwendet wird, um dem Benutzer den Status des Systems zu kommunizieren und dem Benutzer gegebenenfalls zu gestatten, die Steuerungsstrategie zu verändern oder die Systemparameter zu steuern.

4. Gehassistenzsystem nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** das Benutzerschnittstellensubsystem (32) für Therapeuten verwendet wird, um dem Therapeuten den Status des Systems, die Beurteilung der Gehfähigkeiten des Benutzers zu kommunizieren und dem Therapeuten zu gestatten, die Steuerungsstrategie zu verändern oder die Systemparameter zu steuern.

5. Steuerungsverfahren für das System nach einem der vorhergehenden Ansprüche, umfassend die folgenden Schritte:

a) Vergleich (35) der quantifizierten Beurteilung der Absicht des Benutzers in Form eines Signals (34) mit einem Totzeitbereich;
wobei das Verfahren, falls der Absolutwert des Signals kleiner als der festgelegte Totzeitbereichswert ist, mit Schritt e) fortfährt, anderenfalls fährt das Verfahren mit Schritt b) fort,
b) Vergleich (39) der Richtung des Eingangssignals aus Schritt a) mit der bestehenden Bewegungsrichtung der Plattform;
wobei das Verfahren, falls die Richtungen entgegengesetzt sind, mit Schritt c) fortfährt, ansonsten fährt das Verfahren mit Schritt d) fort,
c) exponentielles Bremsen (40), um die Bewegung der Plattform zu einem sanften, jedoch aktiv ausgeführten Stopp zu bringen, wobei die Signalabklingneigung durch die Amplitude des gesteuerten Signals gesteuert wird, dann ist das Verfahren abgeschlossen (38);
d) Steuern (37) der Bewegung der Plattform mittels einer PID-Steuerung, danach ist das Verfahren abgeschlossen (38);
e) Abklingen (36) lassen der Signalwerte, danach ist das Verfahren abgeschlossen (38).

Revendications

1. Système d'aide à la marche comprenant :

- une plate-forme comprenant en outre un châssis de base en forme de U (13) avec deux roues motorisées entraînées par des unités de transmission (8, 9) et avec au moins deux roues non entraînées (10, 11) qui permettent de déplacer la plate-forme à la fois linéairement et en rotation autour d'un axe vertical ;
- un système de support à l'utilisateur comprenant en outre une paire de montants verticaux (3, 5) attachés au moyen de joints de liaison élastiques (6, 7) au châssis de base (13) de la plate-forme, un montant horizontal (2) qui interconnecte la paire de montants verticaux (3, 5) sur son extrémité supérieure, et un harnais d'utilisateur avec des sangles (4) attachées au montant horizontal (2) au moyen desquelles l'utilisateur est sanglé de manière sûre afin d'empêcher l'utilisateur de tomber, les joints de liaison élastiques (6, 7) étant formés de manière à permettre la flexion pivotante des montants (3, 5) à partir de la position verticale neutre (17) ; et
- un système de commande ;

caractérisé en ce que le système comprend en outre un dispositif pour mesurer les flexions des montants (3, 5) par rapport à la position verticale neutre (17), lesdites flexions étant proportionnelles aux forces exercées sur les montants par l'utilisateur

(1),
le système de commande permettant à la plate-forme de suivre activement le mouvement prévu de l'utilisateur sur la base d'un signal reçu du dispositif, et le système de commande étant organisé en groupes logiques ou sous-systèmes comme suit :

◦ un sous-système central de commande (30) faisant office de plaque tournante pour toutes les informations relatives à la commande et réalisant le traitement central des données ;
◦ un sous-système de détermination des intentions de l'utilisateur (29) qui gère la détermination et l'interprétation des intentions de l'utilisateur,
◦ un sous-système d'interface utilisateur (28) conçu pour la communication avec l'utilisateur (1) du système,
◦ un sous-système d'interface utilisateur de thérapeute (32) conçu pour la communication avec le thérapeute qui est responsable du processus de réadaptation, et
◦ un sous-système d'unité de transmission (31) commandant les unités de transmission (8, 9) ;
ledit sous-système central de commande (30) étant interconnecté avec d'autres sous-systèmes mentionnés (29, 28, 32, 31), le sous-système de détermination des intentions de l'utilisateur (29) étant conçu pour commander le mouvement de la plate-forme comme suit :

- lorsqu'il n'y a pas de flexion de la verticale gauche (5) et de la verticale droite (3), le système de commande maintient le mouvement de la plate-forme tel qu'il est,
- lorsque les montants verticaux gauche (5) et droit (3) sont fléchis vers l'avant, le système de commande réagit en accélérant la plate-forme vers l'avant,
- lorsque les montants verticaux gauche (5) et droit (3) sont fléchis vers l'arrière, le système de commande réagit en accélérant la plate-forme vers l'arrière,
- lorsque le montant gauche (5) est fléchi vers l'avant et que le montant droit (3) est fléchi vers l'arrière, le système de commande réagit en tournant la plate-forme dans le sens horaire lorsqu'elle est vue du haut, et
- lorsque le montant gauche (5) est fléchi vers l'arrière et que le montant droit (3) est fléchi vers l'avant, le système de commande réagit en tournant la plate-forme dans le sens anti-horaire lorsqu'elle est vue du haut.

2. Système d'aide à la marche selon la revendication 1, **caractérisé en ce que** le système de commande est organisé en un groupe logique ou sous-système supplémentaire, à savoir un sous-système de navigation (33) qui détermine la relation entre la plate-forme et l'environnement ; ledit sous-système central de commande (30) étant également interconnecté avec le sous-système de navigation (33).

3. Système d'aide à la marche selon la revendication 1 ou 2, **caractérisé en ce que** le sous-système d'interface utilisateur (28) est utilisé pour communiquer à l'utilisateur l'état du système, et éventuellement pour permettre à l'utilisateur de modifier la stratégie de commande ou pour commander les paramètres du système.

4. Système d'aide à la marche selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** le sous-système d'interface utilisateur de thérapeute (32) est utilisé pour communiquer au thérapeute l'état du système, l'évaluation des capacités de marche de l'utilisateur, et pour permettre au thérapeute de modifier la stratégie de commande ou de commander les paramètres du système.

5. Procédure de commande du système selon l'une quelconque des revendications précédentes, comprenant les étapes suivantes :

a) comparaison (35) de l'évaluation quantifiée de l'intention de l'utilisateur sous forme d'un signal (34) avec une bande morte ;
si la valeur absolue dudit signal est inférieure à la valeur spécifiée de la zone morte, la procédure continue avec l'étape e), sinon la procédure continue avec l'étape b),
b) comparaison (39) de la direction du signal d'entrée de l'étape a) avec la direction existante du mouvement de la plate-forme ;
si les directions sont opposées, la procédure continue avec l'étape c), sinon la procédure continue avec l'étape d)
c) freinage exponentiel (40) pour amener le mouvement de la plate-forme à un arrêt en douceur mais activement exécuté, la pente de décroissance du signal étant contrôlée par l'amplitude du signal commandé, puis la procédure est terminée (38) ;
d) commande (37) du mouvement de la plate-forme au moyen d'un régulateur PID, puis la procédure est terminée (38) ;
e) décroissance (36) des valeurs de signal, puis la procédure est terminée (38).

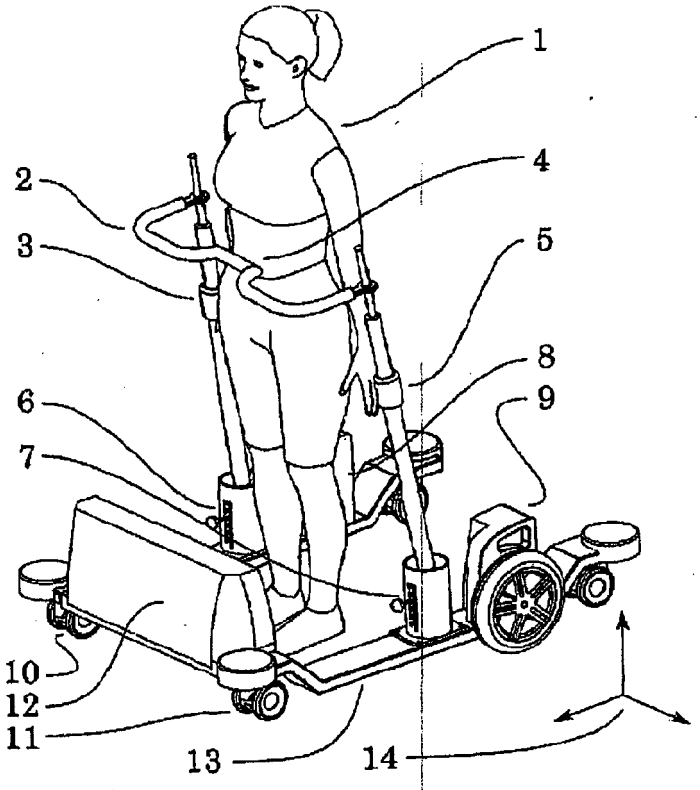

Fig. 1

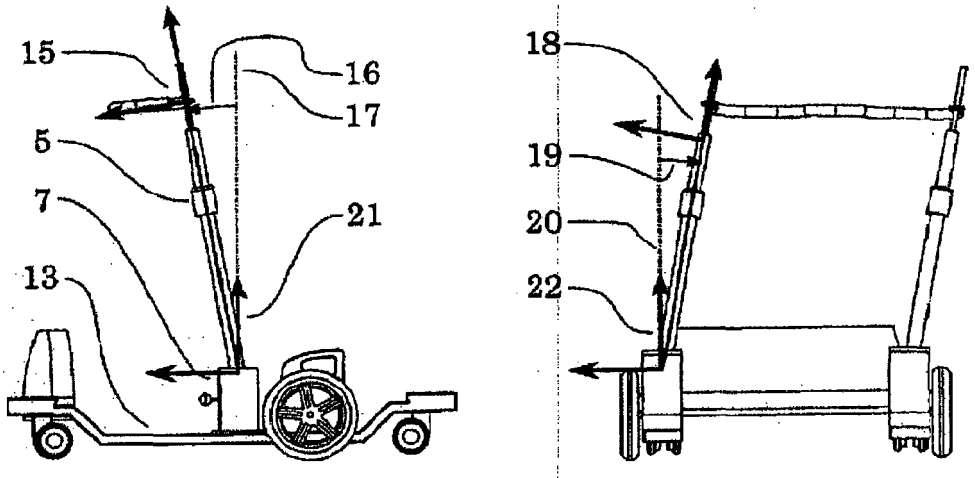

Fig. 2

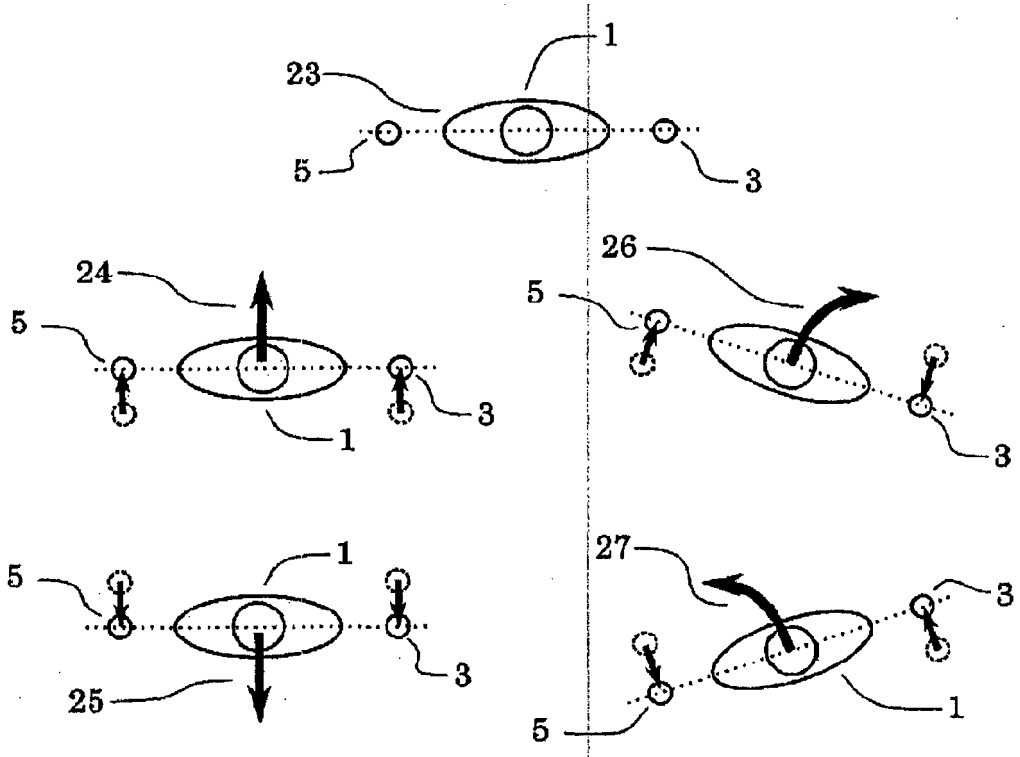
1
23
5
3
24
5
1
3
26
5
3
1
5
3
25
27
3
5
1

Fig. 3

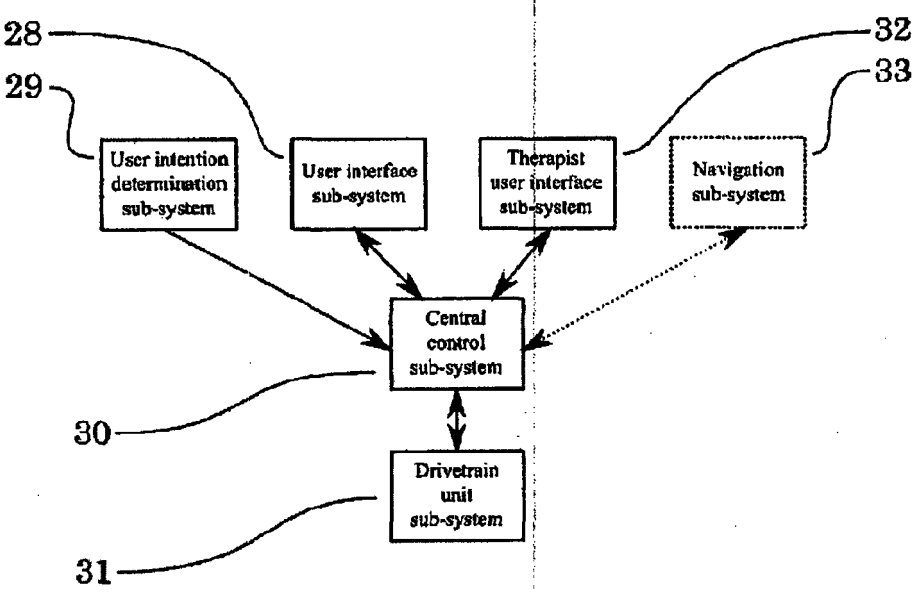
28
29
32
33
User intention determination sub-system
User interface sub-system
Therapist user interface sub-system
Navigation sub-system
Central control sub-system
30
Drivetrain unit sub-system
31

Fig. 4

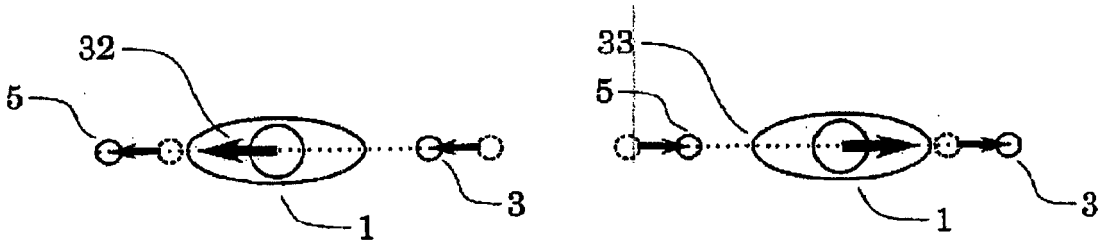
32
5
1
3
33
5
1
3

Fig. 5

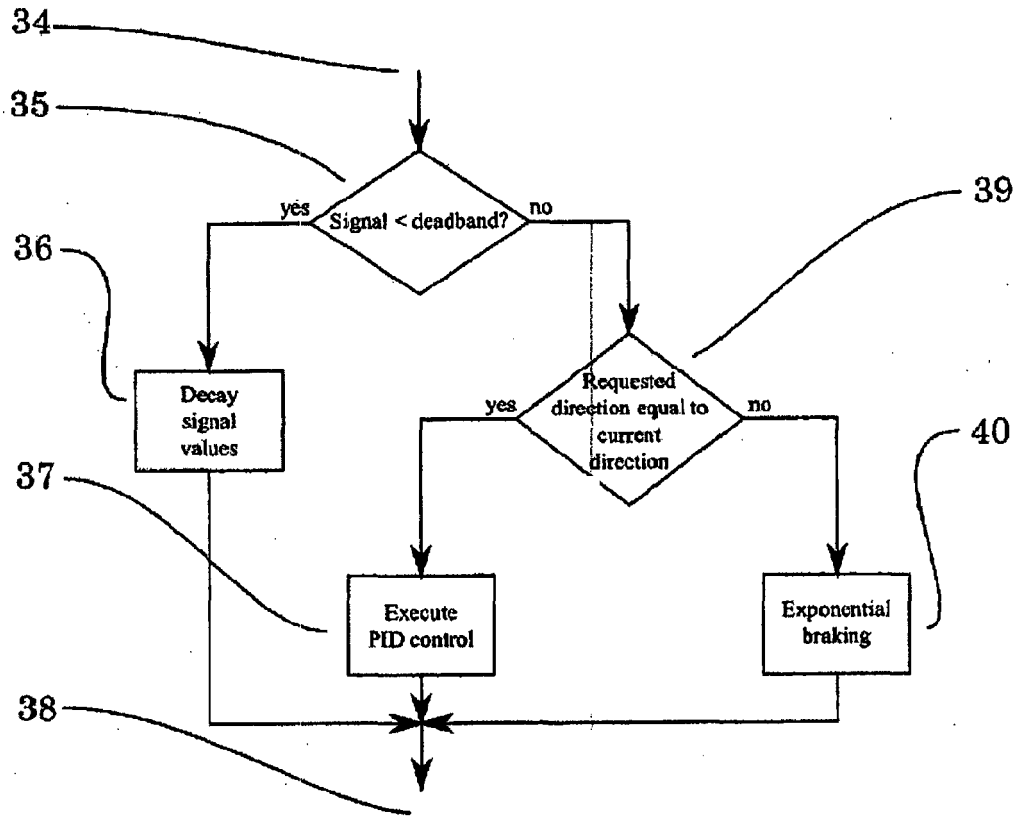
34
35
Signal < deadband?
yes
no
36
Decay signal values
39
Requested direction equal to current direction
yes
no
40
37
Execute PID control
Exponential braking
38

Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- WO 2014081400 A2 **[0020]**