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(54) Title: BODY FALL PROTECTION SYSTEM

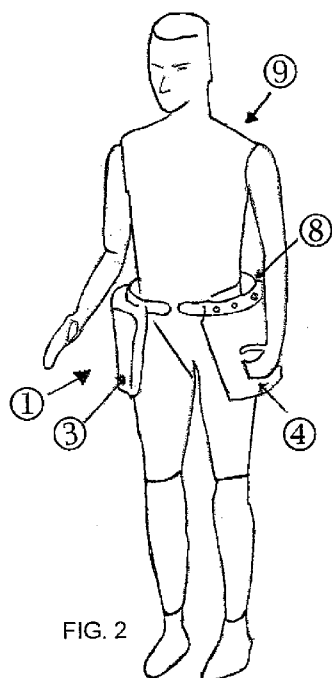


FIG. 2

(57) Abstract: Body fall protection system (1) comprising in combination a device (19) to prevent or to delay completion of the fall and/or an inflatable body wearable device (3, 4) to counter the impact of the fall, and at least one sensor (18) provided on a user's body to collect information about actual body motion, wherein the system (1) comprises a real-time dynamic body model (11) which reflects the human motion based on equations of motion of human bodily parts, which model (11) is monitored with an observer (12) to provide a state estimation (13) of the body based on the real-time dynamic body model (11) and on information collected with the sensor (18), and comprising a decision organ (14) for detecting a fall based on the state estimation (13) provided by the observer (12), wherein the decision organ (14) for detecting the fall controls the device (19) to prevent or to delay completion of the fall respectively controls the inflatable body wearable device (3, 4) to counter the impact of the fall.



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Body fall protection system

The invention relates to a body fall protection system comprising a device to prevent or to delay completion of a fall and/or an inflatable body wearable device to counter the impact of a fall, and at least one sensor provided on a user's body to collect information about actual body motion, which is used to activate the device to prevent or to delay completion of the fall and/or the inflatable body wearable device to counter the impact of the fall.

The article entitled "*Body Fall Detection with Kalman Filter and SVM*", by Paulo Salgado and Paulo Alfonso, published in CONTROLO' 2014 - Proceedings of the 11th Portuguese Conference on Automatic Control, Lecture Notes in Electrical Engineering 321, by A.P. Moreira et. Al.; Springer International Publishing Switzerland 2015 presents an approach for human body fall detection that can be supported with a modern smart phone equipped with accelerator sensors. The article reports that falling is one of the most significant causes of injury, mainly for elderly citizens, and is one of the reasons why many individuals are forced to leave the comfort and privacy of their homes and live in an assisted-care environment. The acceleration measured by the sensor is utilized to collect information about the body motion and is used to develop a robust algorithm to accurately detect a fall. The data is incorporated by a real-time pose body model which is identified with an extended Kalman filter algorithm. Moreover, a support vector machine performs a binary classification of the observed data, allowing the detection of fall incidents. The reported pose body model is purely kinematic, as it does not take into account mass properties (like inertia) and equations of motion of the human upper body. It also does not include a model of the motions of the human lower body (such as the legs), as it does likewise not include control reactions of the human trying to maintain its balance and pace.

US2014/0260714 discloses a portable gyroscopic assisted system mounted on a user's body to influence the ori-

entation of said users having difficulty with balancing during their gait. The system comprises a plurality of sensors to detect a pre-fall condition of the user to control the gyroscopes in order to produce a control moment on the user to prevent or slow down a fall.

WO2012/104833 discloses an active hip protector system to prevent hip fracture. The hip protector system comprises a belt like pouch, worn over the user's waist, containing airbags which are inflated to ensure that the user's thighs will not hit the ground upon impact once the system detects a fall. The system incorporates measurement sensors and acceleration and spatial orientation sensors to enable reliable detection of an impending collision with the ground.

It is an object of the invention to further develop the prior art into a system that provides improved detection of a fall, and is capable to provide better results in preventing the fall or at least reducing the impact.

It is another object of the invention to provide increased accuracy in detecting and protecting against a fall without depending on huge amounts of data in a database in order to classify the observed sensor data for the detection of a fall incident.

It is still another object of the invention to improve the reliability of the detection of a fall incident.

These and other objects of the invention which will become apparent from the following disclosure are provided by a body fall protection system having the features of one or more of the appended claims.

In a first aspect of the invention the system comprises a real-time dynamic body model which reflects the human motion based on equations of motion of human bodily parts, which model is monitored with an observer to provide a state estimation of the body based on the real-time dynamic body model and on information collected with the sensor, and comprising a decision organ for detecting a fall based on the state estimation provided by the observer, wherein the decision organ for detecting the fall controls the device to prevent or to delay completion of the fall respectively controls

the inflatable body wearable device to counter the impact of the fall.

A notable difference that the invention preferably provides over the prior art is that the model defines a relation between forces or torques acting on the bodily parts and movements of such bodily parts, which leads to higher accuracy and reliability in the prediction of an imminent fall and consequently in improved and reliable prevention that the adverse consequences of a fall will materialize.

A feature of the system of the invention is that the said device that is used to prevent or to delay completion of the fall and/or to mitigate the consequences of the fall hinders the user to the least possible extent for which it is preferable that it concerns an active device, wherein the decision organ for detecting the fall controls said device to prevent or to delay completion of the fall respectively controls said device to mitigate the consequences of the fall.

The ease of using the body fall protection system of the invention is promoted by arranging that the at least one sensor and the remainder of the system are integrated with the device to prevent or to delay completion of the fall respectively are integrated with the device to mitigate the consequences of the fall.

In one suitable embodiment the device to prevent or delay completion of the fall is a robotic assistive device. This can be an exoskeleton but preferably this robotic assistive device comprises a backpack containing control moment gyroscopes. An example of that teaches US2014/0260714 A1 and is described in detail in NL 2014927.

In a second aspect of the invention the system comprises as an alternative or in addition to the device to prevent or to delay completion of the fall, an inflatable body wearable device to counter the impact of the fall. Such an inflatable body wearable device is advantageously worn around the waist of the user to prevent the most common injury of a broken hip. For that purpose it is beneficial that the decision organ for detecting the fall controls the inflatable body wearable device to initiate its inflation when a fall is

detected.

Although the invention can be applied with many different models of human movement it is preferred that the real-time dynamic body model comprises a model of one or two rigid or flexible legs, particularly spring legs with linear spring properties. In its simplest embodiment this is an inverted pendulum model, wherein the human upper body is modelled as a point mass located at the hip joint. Such an inverted pendulum model with spring legs is for example disclosed in "Compliant leg behaviour explains basic dynamics of walking and running". Hartmut Geyer,^{1,*} Andre Seyfarth,¹ and Reinhard Blickhan², Proc Biol Sci. 2006 Nov 22; 273(1603): 2861-2867, available at <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1664632/>.

It is further preferred that the model predicts foot placement for which purpose the real-time dynamic body model preferably calculates the relative location of an equivalent ground support point with respect to an upper body's centre of mass.

The location of the equivalent ground support point is preferably calculated from the force F and the moment M obtained from dynamic equilibrium equations, by solving for the vector r in the cross product $M_p = r \times F$ in combination with the assumption that the length of r is equal to the leg length l , whereby r is an unknown vector from the centre of mass of the body to the equivalent ground support point, and M_p is the projection of the moment vector M into a plane that is orthogonal to the direction of F .

The location of the ground support force, also called the centre of pressure, is a valuable and widely used intuitive measure to quantify human balance. When the horizontal distance between the centre of mass and the equivalent ground support point is large, this implies that the user is not in static equilibrium and at risk of falling. Note that this measure does not necessarily quantify the location of a foot on the ground. Instead, it can be a combination of support forces from the legs, the arms, and other body parts, for example when sitting in a chair. Therefore, the measure is

only called an equivalent ground support distance. Regardless of the nature and location of the forces, for static equilibrium the line of action of the resultant force of all these contacts would be vertical and intersect the centre of mass of the concerning person.

Suitably the equivalent ground support point is calculated by combining equations for dynamic equilibrium $F=m*a$ and $M=dH/dt$, with $H=I*\omega$, whereby

F: sum of forces acting on the body

10 m: mass of the body

a: acceleration of the body's centre of mass

M: sum of moments acting on the body, assumed to be caused by the sum of forces F acting at the equivalent ground support point

15 H: angular momentum of the body

I: inertia tensor of the body

ω : angular velocity vector of the body

dH/dt : derivative of angular momentum H with respect to time.

Given the intuitive interpretation of the equivalent ground support distance, this measure can be used for fall detection in a simple way, preferably in such a way that the fall detection system detects a fall when the horizontal distance between the body's centre of mass and the equivalent ground support exceeds a preselected numerical value for multiple time instances. Preferably, this is combined with another threshold on the vertical velocity, in order to avoid false alarms.

The reliability and accuracy of the model for fall detection can be further improved by arranging that the human upper body is modelled as a rigid body with nonzero rotational inertia, with preferably its centre of mass located above the hip joint. Preferably further the real-time dynamic body model predicts hip torques based on the so-called virtual pivot point model. Such a mechanical model of the human body, which includes spring-loaded legs and a rigid upper body and hip torque prediction, is for example disclosed the article "Upright human gait did not provide a major mechanical challenge for our ancestors", by H. M. Maus et. Al., 2010 Macmil-

lan publishers Limited, available online at
www.nature.com/naturecommunications.

Preferably the at least one sensor is an inertial measurement unit which can be provided to a user's body near the waist. More preferably the at least one sensor comprises three inertial measurement units that are placed around a user's body near the waist, suitably arranged symmetrically with two in front and one in the back.

Accuracy is secured by the arrangement that the observer derives from the real-time dynamic body model a state estimation of the body centre of mass position and velocity, and the upper body angular orientation and velocity.

The observer as used in the invention can be combined with conventional kinematic information. In particular, a vertical velocity equivalent of the body can be obtained by integrating the vertical acceleration of the centre of mass, as obtained from an inertial measurement unit placed close to the centre of mass. In order to avoid drift, it is preferable that this integration is only performed when the acceleration in the vertical direction exceeds a given dead band around a static resting position, preferably symmetrical in both directions and preferable approximately based on a gravitational acceleration constant.

One of the nice features of the invention is that the system can differentiate between a fall to the left and a fall to the right based on body angular velocity and body inclination, in order to inflate only a single side of the body wearable device.

A major benefit of using a dynamic model that models the human behaviour as proposed in a system for detecting a fall according to this invention is that extensive databases to derive from the sensor data that a fall may be imminent, are no longer required and that also other information derived of the dynamic model can be reliably used for detecting a fall. The reliability and accuracy of the model for fall detection can be further improved via adaptive control which makes possible that the model parameters can adapt to a particular human subject.

Making use of the mentioned types of real-time dynamic body models it is also possible to reduce on the number of sensors to be applied to monitor actual motion behaviour of the user. In fact it becomes possible that the at least
5 one sensor is a single inertial measurement unit or two or at most three inertial measurement units provided to the user's body near its waist. One important advantage of the invention is that sensors applied to the legs of the user are unnecessary. This highly improves on acceptance of the system for
10 every-day use, particularly also since the single sensor and the further instrumentation embodying the system can be integrated with the device to prevent or to delay completion of the fall and/or the device to reduce the impact of the fall, notably the inflatable wearable device.

15 One aspect of the invention that contributes to the feature that extensive databases are avoided, is that the observer derives from the real-time dynamic body model a state estimation of relevant motion parameters of the body such as the body centre of mass position and velocity, and the upper
20 body angular orientation and velocity.

Accurate use can be made of the estimated states of the user by implementing the observer as a Kalman filter, which filter is known per se to the skilled person. Preferably an unscented Kalman filter or an extended Kalman filter
25 is used.

The invention will hereinafter be further elucidated with reference to the drawing of an exemplary embodiment of an apparatus according to the invention that is not limiting as to the appended claims.

30 In the drawing:

- figure 1 shows a first embodiment of an activated body fall protection system according to the invention;
- figures 2 and 3 show the body fall protection system of figure 1 when worn by a dummy representing a user;
- 35 - figure 4 shows a second embodiment of a body fall protection system according to the invention;
- figure 5 shows a basic scheme of a real-time dynamic body model and an observer of the system shown in fig-

ure 1; and

- figure 6 shows a more detailed representation of the real-time dynamic body model of figure 5.

Whenever in the figures the same reference numerals are applied, these numerals refer to the same parts.

Figure 1 shows a first embodiment of the body fall protection system 1 of the invention, embodied with a belt 8 which can be worn by a user as shown in figure 2 and figure 3. The belt 8 carries inflatables 3, 4 which are activated for illustrative purposes and that serve to mitigate the consequences of the fall. Figure 2 shows the front of a dummy 9 wearing the body fall protection system 1, and figure 3 shows the back of the dummy 9 wearing this fall protection system 1.

Preferably at the back of the belt 8 a main unit 7 is mounted in which at least one sensor (not shown but depicted with reference 18 in figure 5 to be discussed hereinafter) is mounted, which may thus be provided on the body of a user to collect information about the user's actual body motion. It is in some applications preferable that there are three inertial measurement units placed around a user's body near the waist, suitably arranged symmetrically with two in front and one in the back. As will be discussed hereinafter with reference to figures 5 and 6, the main unit 7 also comprises a real-time dynamic body model monitored with an observer to provide a state estimation of the body of the user, and comprises a decision organ for detecting a fall based on the state estimation provided by the observer.

As already mentioned and shown in figure 1, the system 1 comprises an inflatable body wearable device 3, 4 to counter the impact of an unintentional fall of the user. Figure 2 and figure 3 clearly show that the inflatable body wearable device 3, 4 can be worn around the waist of a user. Preferably the at least one sensor in the main unit 7 is an inertial measurement unit. As will be clear from figures 1 - 3, the at least one sensor and the remainder of the system 1 are integrated with the inflatable body wearable device 3, 4 which makes wearing the system easy and contributes to the

acceptance of the system by the intended user.

The main unit 7 preferably includes a CPU connected to the at least one sensor in this unit 7, wherein said CPU is further provided with a memory and arranged to operate according to software implementing the real-time dynamic body model and the observer as well as the decision organ for detecting a fall, as will be explained hereinafter with reference to figures 4 and 5. Furthermore one thing and another is arranged to control the inflatable body wearable device 3, 4 to initiate its inflation when a fall is detected. Figure 3 shows for that purpose pneumatic lines 10 leading from the main unit 7 to the inflatable body wearable device 3, 4 to inflate the tubes within this device.

In figure 4 a second embodiment of the body fall protection system 1 of the invention is shown, embodied again with a belt 8 which can be worn by a user 9. In this embodiment the belt 8 carries a device 19 to prevent or to delay completion of the fall, which is preferably a robotic assistive device 20. The robotic assistive device 20 comprises a backpack 21 containing control moment gyroscopes 22.

Comparable to what is shown in figure 1, at the back of the belt 8 a main unit can be provided in which at least one sensor is mounted, which may thus be provided on the body of the user 9 to collect information about the user's actual body motion. As will be discussed with reference to figures 5 and 6 hereafter, the main unit further comprises a real-time dynamic body model which reflects the human gait based on equations of motion of human bodily parts, preferably including their respective masses and moments of inertia, and monitored with an observer to provide a state estimation of the body of the user 9, and comprises a decision organ for detecting a fall based on the state estimation provided by the observer. When it is thus detected that a fall is imminent, the decision organ activates the device 19 causing that the control moment gyroscopes 22 prevent or delay completion of the fall.

For sake of completeness it is remarked that the device 3, 4 to mitigate the consequences of a fall as shown in

figure 1, and the device 19 to prevent or delay a fall as shown in figure 4 can also be applied simultaneously.

Reference is now made to figures 5 and 6 to explain the real-time dynamic body model and the observer as well as the decision organ for detecting a fall as used in the system 1 of the invention.

In figure 5 a block scheme is provided showing the real-time dynamic body model 11 as used in the invention and monitored with an observer 12 to provide a state estimation 13 of the body of the user. The observer 12 also uses information from the at least one sensor 18 to improve the accuracy of the state estimation 13. A decision organ 14 receives the state estimation 13 and uses this to inflate at the appropriate time the body wearable device 3, 4 of figure 1 when detecting a fall based on the state estimation 13 provided by the observer 12. Alternatively or in addition the decision organ 14 can also activate the device 19 shown in figure 4 when this device is used, which serves to prevent or delay the fall. The manner in which this device operates is explained in US2014/0260714 A1 and is described in NL 2014927.

In figure 6 an exemplary more detailed scheme is provided regarding the real-time dynamic body model 11, which basically may comprise a dynamic model 15 of the human gait applying an extrapolated centre of mass which predicts foot placement, as well as a virtual pivot point model 16 for predicting hip torque. A detailed explanation of these two models is provided by the articles "The extrapolated centre of mass concept suggests a simple control of balance in walking", by At L. Hof, available online at www.sciencedirect.com, Human Movement Science 27 (2008), 112-115, and the article "Upright human gait did not provide a major mechanical challenge for our ancestors", by H. M. Maus et. Al., 2010 Macmillan publishers Limited, available online at www.nature.com/naturecommunications. The content of both articles is deemed incorporated herein by reference.

Preferential features of the real-time dynamic body model 11 as applied in the invention are that the real-time dynamic body model 11 is an inverse-dynamic model that calcu-

lates the relative location of an equivalent ground support point with respect to an upper body's centre of mass. In this connection the mentioned equivalent ground support point is calculated by combining equations for dynamic equilibrium

5 $F = m \cdot a$ and $M = dH/dt$, with $H = I \cdot \omega$, whereby

F : sum of forces acting on the body

m : mass of the body

a : acceleration of the body's centre of mass

M : sum of moments acting on the body, assumed to be caused by

10 the sum of forces F acting at the equivalent ground support point

H : angular momentum of the body

I : inertia tensor of the body

ω : angular velocity vector of the body

15 dH/dt : derivative of angular momentum H with respect to time.

The observer 12 shown in figure 5 derives from the real-time dynamic body model 11 a state estimation of the body centre of mass position and velocity, and the upper body angular orientation and velocity, which are collectively referred to in figure 6 with a single reference 17. The centre of mass position is preferably provided with respect to an equivalent ground support point.

Determining the state estimation preferably includes a feature wherein the observer 12 calculates a vertical velocity equivalent of the body by integrating an acceleration of the centre of mass in vertical direction only when the acceleration in the vertical direction exceeds a preselected dead band around a static resting position, preferably symmetrical in both directions and preferable approximately based on a gravitational acceleration constant.

30 A further preferable feature is that the system differentiates between a fall to the left and a fall to the right based on body angular velocity and body inclination, in order to inflate only a single side of the body wearable device 3, 4.

35 For sake of completeness it is mentioned that the observer 12 is preferably an unscented Kalman filter, although other types of observers are usable as well and can be

selected depending on the circumstances of the case. One notable example is the application of an extended Kalman filter. Another notable example is the embodiment mentioned above wherein the observer computes the forces and moments using inverse dynamics of a mechanical model of the upper body, and derives from these the equivalent ground support distance. In that case, filtering is not strictly necessary.

Although the invention has been discussed in the foregoing with reference to an exemplary embodiment of the body fall protection system of the invention, the invention is not restricted to this particular embodiment which can be varied in many ways without departing from the invention. The discussed exemplary embodiment shall therefore not be used to construe the appended claims strictly in accordance therewith. On the contrary the embodiment is merely intended to explain the wording of the appended claims without intent to limit the claims to this exemplary embodiment. The scope of protection of the invention shall therefore be construed in accordance with the appended claims only, wherein a possible ambiguity in the wording of the claims shall be resolved using this exemplary embodiment.

CLAIMS

1. Body fall protection system (1) comprising in combination a device (19) to prevent or to delay completion of the fall and/or an inflatable body wearable device (3, 4) to counter the impact of the fall, and at least one sensor (18) provided on a user's body to collect information about actual body motion, **characterized in that** the system (1) comprises a real-time dynamic body model (11) which reflects the human motion based on equations of motion of human bodily parts, which model (11) is monitored with an observer (12) to provide a state estimation (13) of the body based on the real-time dynamic body model (11) and on information collected with the sensor (18), and comprising a decision organ (14) for detecting a fall based on the state estimation (13) provided by the observer (12), wherein the decision organ (14) for detecting the fall controls the device (19) to prevent or to delay completion of the fall respectively controls the inflatable body wearable device (3, 4) to counter the impact of the fall.

2. Body fall protection system according to claim 1, **characterized in that** the model (11) defines a relation between forces or torques acting on the bodily parts and movements of such bodily parts.

3. Body fall protection system according to claim 1 or 2, **characterized in that** the at least one sensor (18) and the remainder of the system are integrated with the device (19) to prevent or to delay completion of the fall respectively are integrated with the inflatable body wearable device (3, 4) to mitigate the consequences of the fall.

4. Body fall protection system according to any one of claims 1 - 3, **characterized in that** the device (19) to prevent or delay completion of the fall is a robotic assistive device (20).

5. Body fall protection system according to claim 4, **characterized in that** the robotic assistive device (20) comprises a backpack (21) containing control moment gyroscopes (22).

6. Body fall protection system according to any one of claims 1 - 5, **characterized in that** the inflatable body wearable device (3, 4) is wearable around a user's waist.

7. Body fall protection system according to any one of claims 1 - 6, **characterized in that** the decision organ (14) for detecting the fall controls the inflatable body wearable device (3, 4) to initiate its inflation when a fall is detected.

8. Body fall protection system according to any one of claims 1 - 7, **characterized in that** the real-time dynamic body model (11) comprises a model of one or two rigid or flexible legs, particularly spring legs with linear spring properties.

9. Body fall protection system according to any one of claims 1 - 8, **characterized in that** the real-time dynamic body model (11) calculates the relative location of an equivalent ground support point with respect to an upper body's centre of mass.

10. Body fall protection system according to claim 9, **characterized in that** the equivalent ground support point is calculated by combining equations for dynamic equilibrium $F=m*a$ and $M=dH/dt$, with $H= I*\omega$, whereby

F: sum of forces acting on the body

m: mass of the body

a: acceleration of the body's centre of mass

M: sum of moments acting on the body, assumed to be caused by the sum of forces F acting at the equivalent ground support point

H: angular momentum of the body

I: inertia tensor of the body

ω : angular velocity vector of the body

dH/dt : derivative of angular momentum H with respect to time.

11. Body fall protection system according to any one of claims 1 - 10, **characterized in that** the real-time dynamic body model (11) comprises a model of the human upper body which is modelled as a rigid body with nonzero rotational inertia.

12. Body fall protection system according to any one

of claims 1 - 11, **characterized in that** the real-time dynamic body model (11) comprises a model of the human upper body which is modelled with its centre of mass located above the hip joint.

5 13. Body fall protection system according to any one claims 1 - 12, **characterized in that** the at least one sensor (18) is an inertial measurement unit which can be provided to a user's body near the waist.

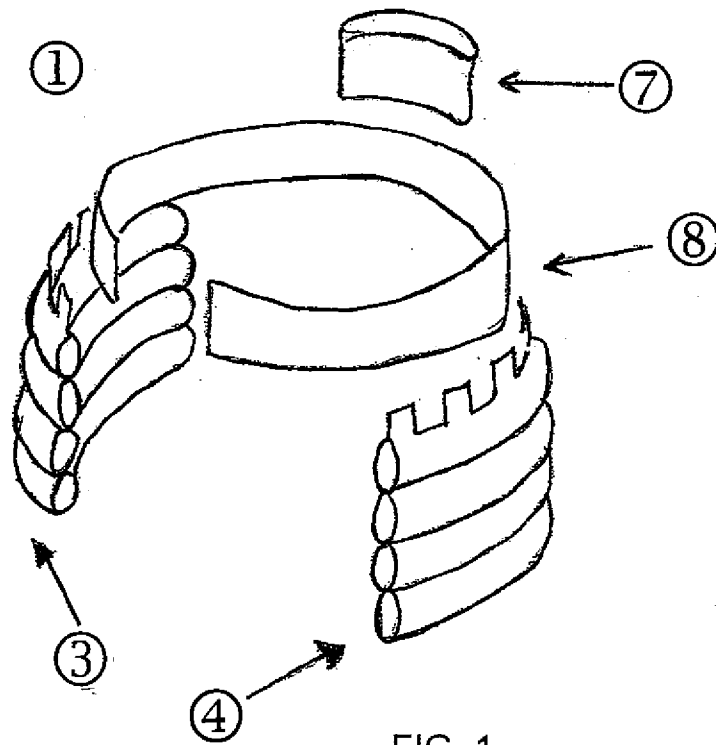
10 14. Body fall protection system according to any one claims 1 - 13, **characterized in that** the at least one sensor (18) comprises three inertial measurement units that are placed around a user's body near the waist, preferably arranged symmetrically with two in front and one in the back.

15 15. Body fall protection system according to any one of claims 1 - 14, **characterized in that** the observer (12) derives from the real-time dynamic body model (11) a state estimation (13) of the body centre of mass position and velocity, and the upper body angular orientation and velocity.

20 16. Body fall protection system according to any of the preceding claims 1-15, **characterized in that** the observer (12) calculates a vertical velocity equivalent of the body by integrating an acceleration of the centre of mass in vertical direction only when the acceleration in the vertical direction exceeds a preselected dead band around a static resting position, preferably symmetrical in both directions and preferably approximately based on a gravitational acceleration constant.

30 17. Body fall protection system according to any of the preceding claims 1-16, **characterized in that** the system differentiates between a fall to the left and a fall to the right, preferably based on body angular velocity and body inclination, in order to inflate only a single side of the body wearable device (3, 4).

35 18. Body fall protection system according to any one of claims 1 - 17, **characterized in that** the observer (12) is a Kalman filter, preferably an unscented Kalman filter or an extended Kalman filter.



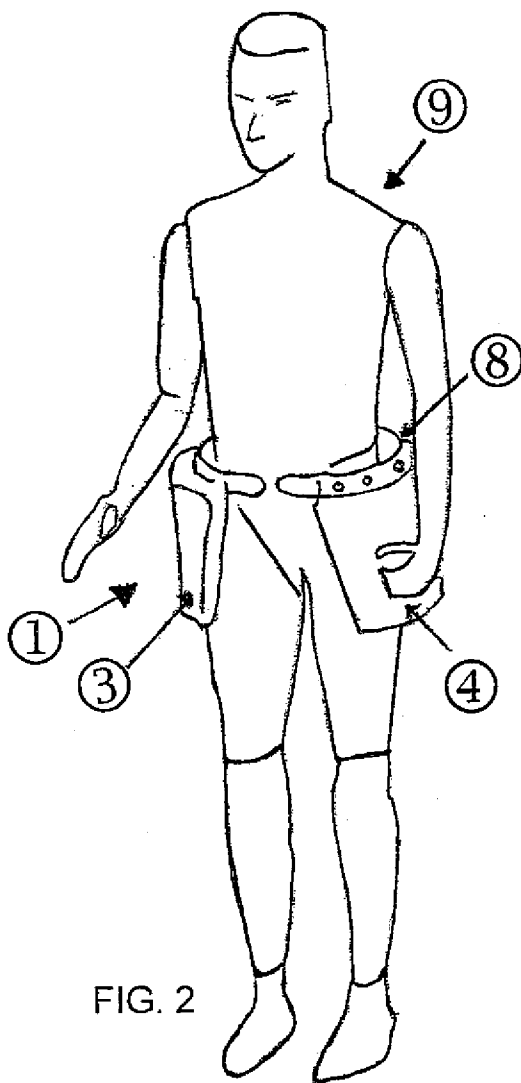


FIG. 2

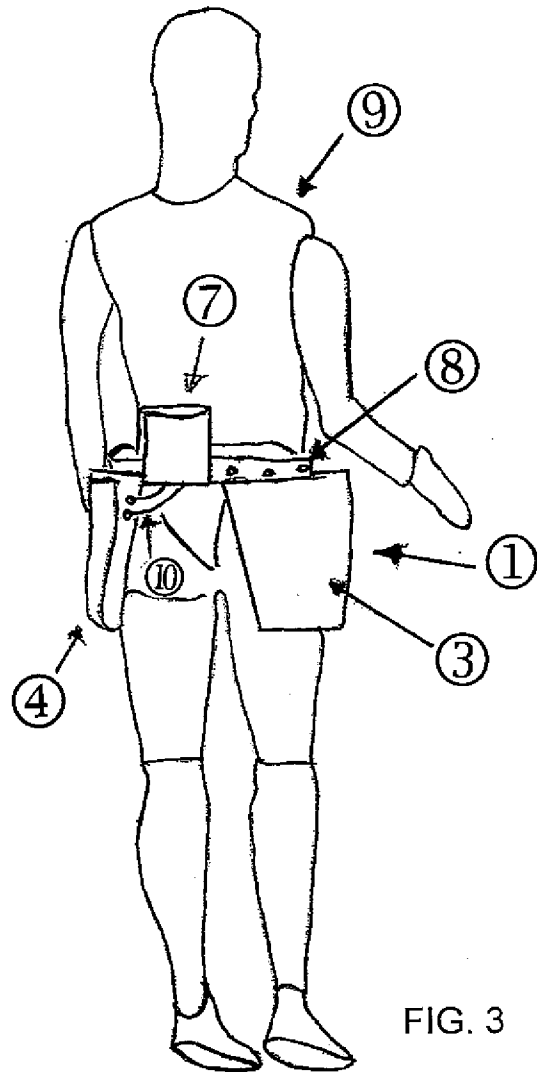
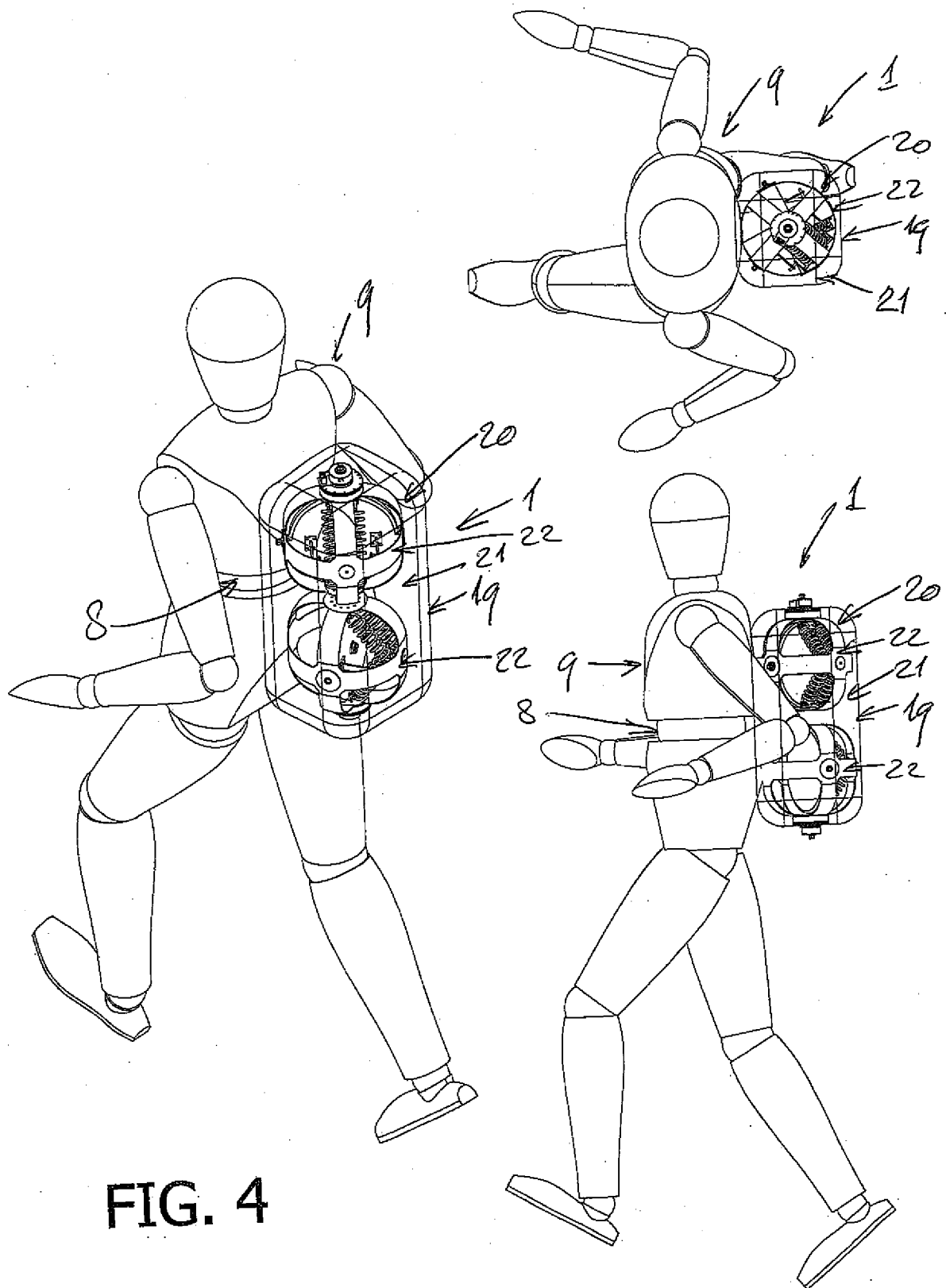
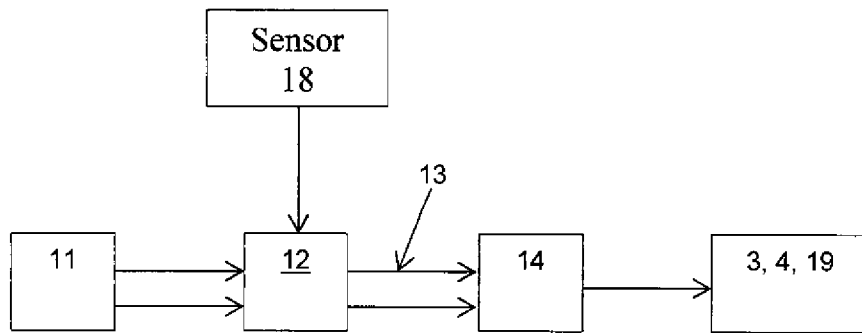
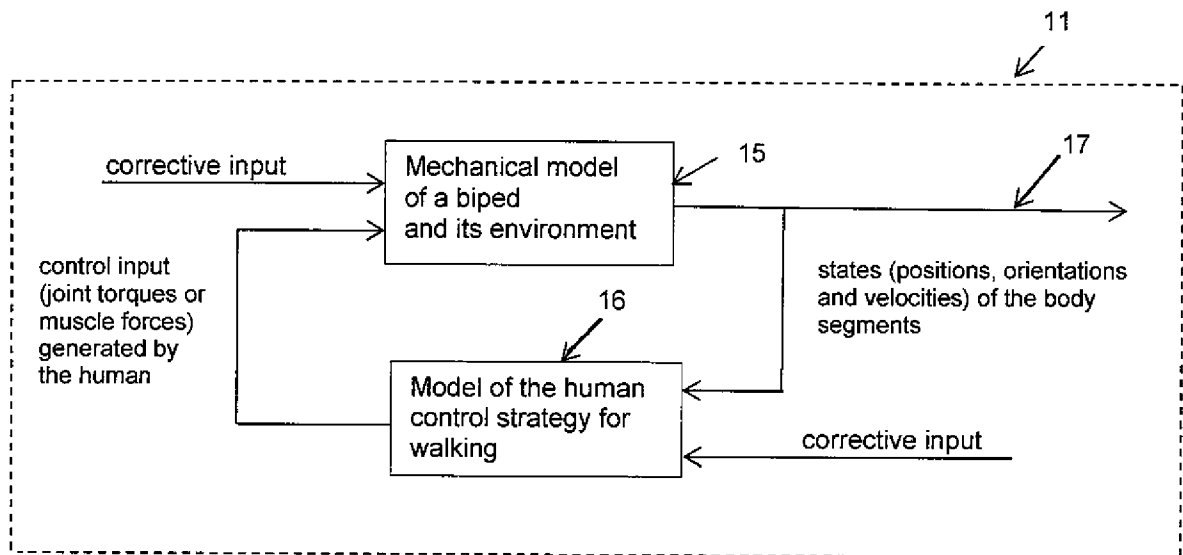


FIG. 3



FIG. 5FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A41D13/018 A61B5/11
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2007/112287 A1 (FANCOURT CRAIG L [US] ET AL) 17 May 2007 (2007-05-17) paragraph [0027] - paragraph [0032] figure 3	1-18
Y	----- US 2014/260714 A1 (VALLERY HEIKE [AE] ET AL) 18 September 2014 (2014-09-18) abstract figure 1	1,2,4,5, 14-18 3,6-13
A	----- WO 2012/104833 A2 (HIP HOPE TECHNOLOGIES LTD [IL]; RAANAN AMATSIA [IL]) 9 August 2012 (2012-08-09) abstract; figure 5	3,6,7,13
Y	----- ----- -/-	1,2,4,5, 8-12, 14-18



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No

PCT/NL2017/050107

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Information on patent family members

International application No

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