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(54) **Method for determining an instant velocity of a user and for improving estimation of heart rate**

Verfahren zur Bestimmung einer Momentangeschwindigkeit eines Benutzers und zur Schätzung der Herzfrequenz

Procédé pour déterminer une vitesse instantanée d'un utilisateur et pour améliorer l'estimation du débit cardiaque

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Description

Field

[0001] The present invention concerns a method for determining an instant velocity of a user when walking or running using a sensing device destined to be worn on an arm of the user. The invention also related to using the instant velocity to improve a heart rate estimation measured with a heart rate sensor.

Description of related art

[0002] Following the increasing market demand, different systems to estimate the speed of a runner (jogger, walker, etc.) have recently been developed. Such systems make use of different measurement principles, such as accelerometer measurement, the use of GPS, measuring Doppler radar or the principle of the pedometer.

[0003] Portable devices for estimating a speed of a runner usually comprise an accelerometer that is arranged such as to measure a vertical component of the acceleration. To that end, the accelerometer is placed on the shoe of the user or fastened to an ankle or knee of the user.

[0004] Other known methods for determining the speed of a runner use a measuring device that is located close to the runner's center of gravity. For example, an accelerometer can be fastened by means of a belt or clip close to the runner's center of gravity, such as the user's torso or head. Pedometers attachable to the pelvis or footwear and based on mechanical pendulums or accelerometers are also reported.

[0005] In EP1862765, an inertial sensor is placed in a wristwatch device at the wrists of a runner. However, the device is used solely for measuring the step frequency associated with the user's stepping. Indeed, the arms follow a very different trajectory from that of the user's center of mass and even briefly return backwards at each step. Such devices are possibly useful for approximately evaluating the distance travelled or the number of calories expended during a running session, but are however incapable of analyzing step length accurately and, consequently the user's speed.

[0006] US2012083705 discloses an activity monitoring system comprising a fixture having size/shape adapted to couple to a location on the user's body and a particular signature; and a portable monitoring device adapted to detect the fixture's particular signature. The monitoring device includes a housing that is adapted to engage the fixture; activity sensors, disposed in the housing, to detect activity of the user and to generate data which is representative of the activity of the user; and processing circuitry, disposed in the housing, to calculate an activity-related quantity of the user using the data which is representative of the activity of the user, wherein the processing circuitry determines the monitoring device is engaging the fixture by detecting the fixture's particular signature, and, in response thereto, calculates the activity-related quantity using data from a set of the activity sensors.

[0007] US2012006112 discloses a method and apparatus of a portable terminal estimate a step length of a pedestrian. An accelerometer detects acceleration caused by a movement of the portable terminal as a pedestrian carrying the portable terminal walks. A gyroscope detects angular velocity caused by the movement of the portable terminal as the pedestrian walks. A controller determines a magnitude of a swinging motion of the portable terminal by using at least one of the detected acceleration and angular velocity, determines that the portable terminal makes the swinging motion when the magnitude of the swinging motion is equal to or greater than a predetermined value, determines a carrying position of the portable terminal in the pedestrian's body by using at least one of the detected acceleration and angular velocity, and estimates a step length of the pedestrian according to the determined carrying position of the portable terminal.

[0008] US2013080255 discloses step detection and step length estimation techniques include detecting salient points in sensor data of one or more sensors. A step frequency is estimated based on a time interval between the detected salient points. A step length of the step may then be computed based on a nonlinear combination of the estimated step frequency and a function of the sensor data, and/or a step model. Alternatively, the step length of the step may be computed based on a combination of a nonlinear function of the estimated step frequency and a (linear or nonlinear) function of the sensor data, and/or a step model.

[0009] The publication Tracking Fitness With the "Heart Rate-Running Speed Index" by Alex Hutchinson discloses an index which represents the different between the average speed of a run of a user to a theoretical speed calculated based on average heat rate of the user during the run. If the actual speed is faster than the predicted speed, it suggests an improvement in fitness since the baseline value of the index was calculated.

Summary

[0010] One aim of the present invention is to propose a method free from the limitations of the known methods, in particular a method that makes it possible to determine in a simple manner a velocity of a runner (or walker) using a motion signal measured at the wrist of the user.

[0011] These aims are achieved notably by a method according to the claims. Preferred embodiments are described in the dependent claims.

[0012] In an embodiment, the instant velocity is used for estimating an a priori heart rate of the user, a distance travelled by the user, or an energy expenditure of the user.

[0013] In another embodiment, the proposed system is used in conjunction with an optical measurement system. An a priori estimation of the current heart rate in obtained by the combination of the estimated velocity and a model that relates heart rate and velocity. This a priori heart rate is then used to improve the robustness of the estimation of the heart rate using the optical signals when their quality is poor. Controversy, when the quality of the optical signals is good the model relating the velocity to the a priori heart rate is adapted to the specificities of the user.

Brief Description of the Drawings

[0014] The invention will be better understood with the aid of the description of an embodiment given by way of example and illustrated by the figures, in which:

Fig. 1 illustrates schematically a sensor device for measuring a motion signal representative of the user's movements and a photoplethysmographic signal.

Detailed Description of possible embodiments

[0015] Fig. 1 illustrates schematically a sensor device 1 suitable for wearing on a wrist of user comprises a motion sensor 2 for measuring a motion signal representative of the user's movements. In the example of Fig. 1, the sensor device 1 is shown comprising a housing 10 and a strap 5 for attaching the sensor device 1 on the user's wrist. The motion sensor 2 is preferably adapted for measuring motion in three dimensions. For example, the motion sensor 2 can be a three dimensional accelerometer such as a MEMS-based accelerometer adapted to deliver an acceleration (or motion) signal along three axes. It will however be appreciated that other types of accelerometers or motion detecting devices can be used provided they deliver a reliable measure of motion. For example, the motion sensor 2 could be a gyro-sensor of any suitable technology incorporating a one or multidimensional accelerometer, or a rotating or vibrating. The motion sensor 2 can further comprise an ADC module (not shown) outputting acquired motion signal.

[0016] Although the sensor device 1 is shown as being worn on a wrist of the user, it is understood that the sensor device 1 is adapted to be worn on an arm of the user. A different calibration factor for the sensor device 1 could however be needed depending on the possible different locations of the sensor device 1 on the arm.

[0017] Calculating an activity level of the user using the measured motion signal is carried out by calculating an energy value from the motion signal, for example using the norm of the motion signal. The calculated energy value is compared with a threshold energy such that when the calculated energy value is equal or below the threshold energy the user can be considered at rest. Conversely, when the calculated energy value is above the threshold energy the user is considered as performing an activity.

[0018] In the case the calculated energy value is above the threshold energy, calculating an activity level further comprises detecting segments of the measured motion signal having rhythmical characteristics, for example, by frequency spectral analysis of the motion signal. The fundamental movement frequency is then extracted from the motion signal through one of the following technique: zero-crossing, parametric or non-parametric spectral estimation, autocorrelation, recurrence plots, and adaptive filters.

[0019] The fundamental movement frequency is then combined with the calculated energy in order to differentiate between an activity level of the user corresponding to walking, running or another type of rhythmical activity. For example, the ratio of the fundamental movement frequency over the calculated energy can be used for identifying when the user is walking or running. The classification of the activity when a rhythmical motion is detected is based on two features: the amplitude of the motion and the motion frequency. The orientation of the device in the gravity field is used as an additional feature (generally the fore-arm is close to vertical during walking and close to horizontal during running). Classical classification methods such as Bayesian classifiers, artificial neural network (ANN) of hidden Markov models (HMM) can be used. If not explicitly included in the model (such as in HMM) constraints have to be applied to the output of the classification system in order to discard short duration events (such as checking the display of the device) that would result in misclassification errors and lead to erroneous estimation of the estimated velocity.

[0020] During walking or running, the position of the user's legs relatively to the floor can be divided into two phases: on-floor (impact of the user's foot on the ground) and off-floor (propulsive impulsion of the user's step or propulsive phase). This alternate of impact and propulsive phases produce a rotation moment on the trunk that has to be compensated in order to provide an efficient locomotion. This compensation is provided by a counter-moment provided by the arms moving in anti-phase with the legs. The estimation of the counter-moment produced by the arms is related to the moment produced by the impact and the propulsion phases of the legs. The compensation further depends on the mass and the length of the user's arms as well as on the angle of the elbow. The inertia moment is related to the mass distribution relatively to the center of rotation. The arm has two degrees of freedom: the shoulder and the elbow. The shoulder is the center of rotation for the damping system (arm). Depending on the velocity and on the walking/running preferences of the user the elbow's angle can vary between approximately 180° (generally during walking activity) and approximately 90° (generally during running activity). The changes of the elbow's angle modify the mass distribution relatively to the shoulder rotation center and therefore modify the inertia moment of the arm. In the present invention the orientation of the motion sensor 2 relatively to the gravity field is used to estimate the angle of the elbow and to compensate the value of the inertia moment of the arm accordingly.

[0021] In an embodiment, the bio-mechanical model comprises an active damper model wherein the arms act as an active damper of the torque produced by the propulsive phase of the legs. The angle of the elbow can be used in the active damper model to compensate the inertia moment of the arm accordingly to the different position of the arm. For example, the arm positions are different between walking and running.

[0022] The step frequency is estimated by using the motion features. The step frequency can be estimated either by the estimation of time intervals between repetitive events in the acceleration signal (e.g. maxima, minima or zero-crossings), by applying an adaptive filter to track the dominant frequency or by applying a spectral transformation such as Fourier transform and by determining the dominant frequency.

[0023] The step length is dependent on the user, i.e., user's leg length, user's weight, user's running style, etc. Therefore, a user-relative step length is first estimated by using the motion features. A step length can then be determined by using a user-specific calibration. For example, the user-relative step length can be multiplied by a user-specific calibration factor.

[0024] The user-specific calibration factor can be obtained by performing a calibration session where an average velocity is measured. The user-specific calibration factor is then calculated as the ratio of the measured average velocity over the user-relative instant. Alternatively, the calibration factor is obtained by performing a calibration session where a distance travelled by the user is measured. The calibration factor is then calculated as the ratio of the measured distance over a user-relative distance.

[0025] In another variant, the calibration factor is estimated by using morphological parameters of the user in combination with an empirically determined model. The model has to be determined by using measurements from a sufficiently large population of users that spans over the selected set of morphological parameters. The morphological parameters can comprise any one of: gender, age, weight, height, legs' length of the user, or a combination of two or more of the parameters.

[0026] The user-relative instant velocity can be determined by multiplying the estimated step frequency with the estimated step length. The instant velocity is obtained by multiplying the relative velocity by the calibration factor.

[0027] In an embodiment, the distance travelled by the user is estimated by using the instant velocity. The estimated distance can then be used for estimating the step length.

[0028] In another embodiment, an energy expenditure of the user is calculated using the instant velocity. For example, the user's energy expenditure can correspond to the instant velocity multiplied by the weight of the user.

[0029] In yet another embodiment, the method further comprises a step of estimating an a priori heart rate of the user using the determined instant velocity and a model relating the heart rate value with the instant velocity. The a priori heart rate can be determined using a linear or non-linear relationship between the determined instant velocity and the heart rate value. The relationship between velocity and heart rate can be identified using recordings of a representative population of users for different running speeds. Since such regressions are user dependent, the method can further comprise the step of using a physiological model including one of age, gender, weight or height of the user.

[0030] In yet another embodiment, the sensing device 1 further comprises a heart rate sensor for measuring a heart rate signal when the sensing device 1 is worn on the arm of the user. The heart rate sensor can be any suitable device for measuring a heart rate signal such as a photoplethysmographic sensor, an electrocardiogram (ECG) or any heart rate estimation system. The a priori heart rate can then be used as additional information about heart rate to improve the measured heart rate estimated from the heart rate signal when the quality of the heart rate signal degrades. In the example of Fig. 1, the heart rate sensor is a photoplethysmographic (PPG) sensor 3, 4 adapted to measure a PPG signal when the sensing device 1 is worn on the user's arm. The motion sensor 2 and the heart rate sensor can be placed in the sensor device 1 such as to form an integrated sensor device. In this latter configuration, the motion signal is better correlated with the measured PPG signal than if the motion sensor 2 is placed further from the multichannel PPG sensor.

[0031] A reliability of the measured heart rate can be determined such as to determine when the measured heart rate reliable or unreliable (for example due to motion artifacts). In the case where the measured heart rate is unreliable, the a priori heart rate can be used in combination with the measured heart rate such as to obtain a more robust value for the measured heart rate.

[0032] The a priori heart rate supplies additional information for the estimation of the measured heart rate. For example, when the heart rate sensor fails to estimate the measured heart rate with sufficient reliability, the a priori heart rate can be used to improve the performance of the heart rate sensor. On the other hand, when the heart rate sensor estimates a measured heart rate with sufficient reliability, the measured heart rate obtained from the heart rate sensor can be used alone. Such a reliable measured heart rate obtained during walking or running can be used to adapt the model relating the velocity to the motion heart rate to the user's specificities.

[0033] In an embodiment, the a priori heart rate is used to filter the measured heart rate around the value of the a priori heart rate.

[0034] In an embodiment not represented, the sensor device 1 further comprises a display arranged for displaying the measured heart rate and/or a priori heart rate. The display can be arranged on the arm of the user, for example by being integrated to the sensor device 1 itself, or in any other location of the user. The display can be further arranged for displaying any other information including the calculated activity level, the determined instantaneous velocity, the energy expenditure, or the estimated travelled distance.

Reference numbers

[0035]

1	sensor device
2	motion sensor
3	light source
4	optical receiver
5	strap
10	housing
A	first axe
B	second axe

Claims

1. Method for determining an instant velocity of a user using a sensing device (1) destined to be worn on an arm of the user and comprising a motion sensor (2) for measuring and delivering a motion signal representative of the user's movements when the sensing device (1) is worn; the method comprising:

    measuring the motion signal;
    calculating an activity level of the user by calculating an energy value from the measured motion signal;
    comparing the calculated energy value with a threshold energy;
    in the case the calculated energy value is above the threshold energy, detecting segments of the measured motion signal having rhythmical characteristics and, based thereon, estimating a fundamental movement frequency of the user from the measured motion signal;
    identifying when the user is walking or running by combining the calculated energy value of the user using the measured motion signal and the fundamental movement frequency, identifying when the user is walking or running being based on two features including the amplitude of the motion and the motion frequency and on another feature being the orientation of the sensing device in the gravity field;
    when the user is walking or running, providing a relationship between the measured motion signal and corresponding motion features that relate to a propulsive phase of a user's step alternating with an impact of the user's foot on the ground by using a bio-mechanical model of human locomotion;
    wherein said bio-mechanical model comprises an estimation of the counter-moment produced by the arms in relation to the moment produced by the impact and the propulsion phases of the legs; and
    wherein the method further comprises the step of estimating the angle of the arm's elbow by using said another feature being the orientation of the sensing device, comprising the motion sensor (2), in the gravity field;
    estimating a frequency of the user's step and estimating a user-relative step length of the user's step using the motion features;
    determining a user-relative instant velocity by combining the estimated user's step frequency and the estimated user-relative step length; and
    determining the instant velocity by multiplying the user-relative instant velocity by a calibration factor.

2. Method according to claim 1, wherein the calibration factor is determined using one of: cumulated distance when the user is walking or running, average velocity of the user when walking or running, or a morphological parameter of the user.

3. Method according to claim 1, wherein said model comprises an active damper model provided by the motion of the arm.

4. Method according to claim 1 or 2, wherein said estimating a step frequency comprises identifying a time of impact of the user's foot using the motion features in combination with a mass-spring model.

5. Method according to any one of claims 1 to 3, wherein said estimating a user-relative step length further comprises using a calibration measurement taken at the determined instant velocity or at an estimated travelled distance by the user.

6. Method according to any one of claims 1 to 4, wherein combining the estimated step frequency and the estimated user-relative step length comprises multiplying the estimated step frequency with the estimated user-relative step length.

7. Method according to any one of claims 1 to 5, further comprising multiplying the estimated user-relative step length by the calibration factor.

8. Method according to claim 6, wherein the calibration factor is obtained by measuring an average velocity or a distance travelled by the user when the user is walking or running.

9. Method according to claim 6, wherein the calibration factor is estimated by using morphological parameters of the user in combination

with an empirically determined model.

10. Method according to any one of claims 1 to 9, further comprising estimating an a priori heart rate of the user by using the determined instant velocity and a model relating a heart rate value with the instant velocity.

11. Method according to claim 10, wherein the model comprises a linear or a non-linear relationship between the determined instant velocity and said heart rate value.

12. Method according to claim 10, wherein the model comprises a physiological model including one of age, gender, weight or height of the user.

13. Method according to any one of claims 10 or 12, wherein the sensing device (1) further comprises a heart rate sensor (4, 5) adapted to measure a heart rate signal when the sensing device (1) is worn; and wherein the method further comprises measuring the heart rate signal and estimating a measured heart rate from the measured heart rate signal.

14. Method according to claim 13, wherein said estimating a measured heart rate comprises determining a reliability of the measured heart rate; and wherein the a priori heart rate is used in combination with the measured heart rate when the measured heart rate is unreliable.

15. Method according to claim 14, further comprising user-specifically adapting the model by using the measured heart rate when the measured heart rate is reliable.

16. Method according to any one of claims 1 to 12, further comprising estimating a distance travelled by the user by using the integration of the determined instant velocity.

17. Method according to any one of claims 1 to 13, further comprising calculating an energy expenditure of the user by using the determined instant velocity.

Patentansprüche

1. Verfahren zum Bestimmen einer augenblicklichen Geschwindigkeit eines Benutzers unter Verwendung einer Erfassungsvorrichtung (1), welche dazu bestimmt ist, an einem Arm des Benutzers getragen zu werden, und umfassend einen Bewegungssensor (2) zum Messen und Liefern eines Bewegungssignals, das die Bewegungen des Benutzers darstellt, wenn die Erfassungsvorrichtung (1) getragen wird; wobei das Verfahren umfasst:

Messen des Bewegungssignals;
Berechnen eines Aktivitätsniveaus des Benutzers durch Berechnung eines Energiewerts aufgrund des gemessenen Bewegungssignals;
Vergleichen des berechneten Energiewerts mit einer Schwellenenergie;
im Fall, wo der berechnete Energiewert über der Schwellenenergie liegt, Ermitteln von Segmenten des gemessenen Bewegungssignals mit rhythmischen Eigenschaften und, aufgrund davon, Schätzen einer Grundbewegungsfrequenz des Benutzers aufgrund des gemessenen Bewegungssignals;
Identifizieren, wann der Benutzer geht oder läuft, durch Kombinieren des gemessenen Bewegungssignals und der Grundbewegungsfrequenz; wobei das Identifizieren, wann der Benutzer geht oder läuft, auf zwei Merkmalen basiert, einschliesslich Amplitude der Bewegung und Bewegungsfrequenz, und auf einem anderen Merkmal, welche die Orientierung der Erfassungsvorrichtung im Gravitationsfeld ist;
wenn der Benutzer geht oder läuft, Bereitstellen einer Beziehung zwischen dem gemessenen Bewegungssignal und entsprechenden Bewegungsmerkmalen, welche sich auf einer Antriebsphase eines Schrittes eines Benutzers bezieht, abwechselnd mit einem Aufprall des Fusses des Benutzers auf dem Grund, unter Verwendung eines biomechanischen Modells der menschlichen Fortbewegung;
worin das besagte biomechanische Modell eine Schätzung eines durch die Arme erzeugten Gegenmoments in Bezug auf den durch den Aufprall und die Antriebsphasen der Beine erzeugten Moment umfasst; und
worin das Verfahren zudem den Schritt umfasst, den Winkel des Armenellbogens zu schätzen, unter Verwendung des besagten anderen Merkmals, welche die Orientierung der Erfassungsvorrichtung mit dem Bewegungssensor (2) im Gravitationsfeld ist;
Schätzen einer Schrittfrequenz des Benutzers und Schätzen einer benutzerspezifischen Schrittlänge des Schrittes des Benutzers unter Verwendung der Bewegungsmerkmale;
Bestimmen einer benutzerspezifischen augenblicklichen Geschwindigkeit durch Kombinieren der geschätzten Schrittfrequenz des Benutzers und der geschätzten benutzerrelevanten Schrittlänge; und
Bestimmen der augenblicklichen Geschwindigkeit durch Multiplizieren der benutzerspezifischen augenblicklichen Geschwindigkeit durch einen Kalibrierungsfaktor.

2. Verfahren gemäss Anspruch 1, worin der Kalibrierungsfaktor unter Verwendung einer der folgenden Methoden bestimmt wird: kumulierte Distanz beim Gehen oder Laufen des Benutzers, durchschnittliche Geschwindigkeit des Benutzers beim Gehen oder Laufen, oder einen morphologischen Parameter des Benutzers.

3. Verfahren gemäss Anspruch 1, worin das besagte Modell ein aktives Dämpfermodell umfasst, das durch die Bewegung des Arms geliefert wird.

4. Verfahren gemäss Anspruch 1 oder 2, worin das besagte Schätzen einer Schrittfrequenz das Identifizieren einer Aufprallzeit des Fusses des Benutzers unter Verwendung der Bewegungsmerkmale in Kombination mit einem Masse-Feder-Modell umfasst.

5. Verfahren gemäss einem der Ansprüche 1 bis 3, worin das besagte Schätzen einer benutzerspezifischen Schrittlänge zudem das Verwenden einer Kalibrierungsmessung umfasst, welche bei der ermittelten augenblicklichen Geschwindigkeit oder bei einer geschätzten, durch den Benutzer zurückgelegten Distanz.

6. Verfahren gemäss einem der Ansprüche 1 bis 4, worin das Kombinieren der geschätzten Schrittfrequenz und der geschätzten benutzerspezifischen Schrittlänge das Multiplizieren der geschätzten Schrittfrequenz mit der geschätzten benutzerspezifischen Schrittlänge umfasst.

7. Verfahren gemäss einem der Ansprüche 1 bis 5, zudem umfassend das Multiplizieren der geschätzten benutzerspezifischen Schrittlänge mit einem Kalibrierungsfaktor.

8. Verfahren gemäss Anspruch 6, worin der Kalibrierungsfaktor durch Messen einer Durchschnittsgeschwindigkeit oder einer durch den Benutzer zurückgelegten Distanz beim Gehen oder Laufen des Benutzers erhalten wird.

9. Verfahren gemäss Anspruch 6, worin der Kalibrierungsfaktor unter Verwendung morphologischer Parameter des Benutzers in Kombination mit einem empirisch bestimmten Modell geschätzt wird.

10. Verfahren gemäss einem der Ansprüche 1 bis 9, zudem umfassend das Schätzen einer A-priori-Herzfrequenz des Benutzers unter Verwendung der ermittelten augenblicklichen Geschwindigkeit und eines Modells, das einen Herzfrequenzwert mit der augenblicklichen Geschwindigkeit in Beziehung setzt.

11. Verfahren gemäss Anspruch 10, worin das Modell eine lineare oder eine nichtlineare Beziehung zwischen der ermittelten augenblicklichen Geschwindigkeit und dem Herzfrequenzwert umfasst.

12. Verfahren gemäss Anspruch 10, worin das Modell ein physiologisches Modell umfasst, welches Alter, Geschlecht, Gewicht oder Grösse des Benutzers umfasst.

13. Verfahren gemäss einem der Ansprüche 10 oder 12, worin die Erfassungsvorrichtung (1) zudem einen Herzfrequenzsensor (4, 5) umfasst, welcher dazu ausgelegt ist, ein Herzfrequenzsignal zu messen, wenn die Erfassungsvorrichtung (1) getragen wird; und worin das Verfahren zudem das Messen des Herzfrequenzsignals und das Schätzen einer gemessenen Herzfrequenz aus dem gemessenen Herzfrequenzsignal umfasst.

14. Verfahren gemäss Anspruch 13, worin das besagte Schätzen einer gemessenen Herzfrequenz das Bestimmen einer Zuverlässigkeit der gemessenen Herzfrequenz umfasst; und worin die A-Priori-Herzfrequenz in Kombination mit der gemessenen Herzfrequenz verwendet wird, wenn die gemessene Herzfrequenz unzuverlässig ist.

15. Verfahren gemäss Anspruch 14, zudem umfassend das benutzerspezifische Anpassen des Modells unter Verwendung der gemessenen Herzfrequenz, wenn die gemessene Herzfrequenz zuverlässig ist.

16. Verfahren gemäss einem der Ansprüche 1 bis 12, zudem umfassend das Schätzen einer vom Benutzer zurückgelegten Distanz unter Verwendung der Integration der ermittelten augenblicklichen Geschwindigkeit.

17. Verfahren gemäss einem der Ansprüche 1 bis 13, zudem umfassend das Berechnen eines Energieverbrauchs des Benutzers unter Verwendung der ermittelten augenblicklichen Geschwindigkeit.

Revendications

1. Procédé de détermination de la vitesse instantanée d'un utilisateur à l'aide d'un dispositif de détection (1) destiné à être porté sur un bras de l'utilisateur et comprenant un capteur de mouvement (2) pour mesurer et délivrer un signal de mouvement représentant les mouvements de l'utilisateur lorsque le dispositif de détection (1) est porté; le procédé comprenant:

de mesurer le signal de mouvement;
de calculer un niveau d'activité de l'utilisateur en calculant une valeur énergétique à partir du

signal de mouvement mesuré ;
de comparer la valeur énergétique calculée avec une énergie de seuil ;
dans le cas où la valeur énergétique calculée est supérieure à l'énergie de seuil, de détecter des segments du signal de mouvement mesuré ayant des caractéristiques rythmiques et, sur cette base, d'estimer une fréquence de mouvement fondamentale de l'utilisateur à partir du signal de mouvement mesuré ;
d'identifier lorsque l'utilisateur marche ou court en combinant la valeur énergétique calculée de l'utilisateur au moyen du signal de mouvement mesuré et de la fréquence de mouvement fondamentale, le fait d'identifier lorsque l'utilisateur marche ou court étant basé sur deux caractéristiques y compris l'amplitude du mouvement et la fréquence du mouvement et sur une autre caractéristique, étant l'orientation du dispositif de détection dans le champ gravitationnel ;
lorsque l'utilisateur marche ou court, d'établir une relation entre le signal de mouvement mesuré et les caractéristiques de mouvement correspondantes qui se rapportent à une phase de propulsion du pas de l'utilisateur avec un impact du pied de l'utilisateur sur le sol en utilisant un modèle biomécanique de la locomotion humaine;
dans lequel ledit modèle biomécanique comprend une estimation du couple antagoniste produit par les bras en relation au couple produit par l'impact et les phases de propulsion des jambes ; et
dans lequel le procédé comprend en outre l'étape d'estimer l'angle du coude du bras au moyen de ladite autre caractéristique, étant l'orientation du dispositif de détection, compris dans le capteur de mouvement (2), dans le champ gravitationnel ;
d'estimer une fréquence du pas de l'utilisateur et d'estimer une longueur de pas, liée à l'utilisateur, du pas de l'utilisateur en utilisant les caractéristiques de mouvement;
de déterminer une vitesse instantanée relative à l'utilisateur en combinant la fréquence estimée de pas de l'utilisateur et la longueur estimée de pas liée à l'utilisateur; et
de déterminer la vitesse instantanée en multipliant la vitesse instantanée relative à l'utilisateur par un facteur d'étalonnage.

2. Procédé selon la revendication 1, dans lequel le facteur d'étalonnage est déterminé en utilisant l'un des éléments suivants : distance cumulée lorsque l'utilisateur marche ou court, vitesse moyenne de l'utilisateur lors de la marche ou de la course, ou un paramètre morphologique de l'utilisateur.

3. Procédé selon la revendication 1, dans lequel ledit modèle comprend un modèle d'amortissement actif fourni par le mouvement du bras.

4. Procédé selon la revendication 1 ou 2, dans lequel ladite estimation d'une fréquence de pas comprend l'identification d'un temps d'impact du pied de l'utilisateur en utilisant les caractéristiques de mouvement en combinaison avec un modèle masse-ressort.

5. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel ladite estimation d'une longueur de pas liée à l'utilisateur comprend en outre l'utilisation d'une mesure d'étalonnage prise à la vitesse instantanée déterminée ou à une distance estimée parcourue par l'utilisateur.

6. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel la combinaison de la fréquence estimée de pas et de la longueur estimée de pas liée à l'utilisateur comprend la multiplication de la fréquence estimée de pas avec la longueur estimée de pas liée à l'utilisateur.

7. Procédé selon l'une quelconque des revendications 1 à 5, comprenant en outre la multiplication de la longueur estimée de pas liée à l'utilisateur par le facteur d'étalonnage.

8. Procédé selon la revendication 6, dans lequel le facteur d'étalonnage est obtenu en mesurant une vitesse moyenne ou une distance parcourue par l'utilisateur lorsque l'utilisateur marche ou court.

9. Procédé selon la revendication 6, dans lequel le facteur d'étalonnage est estimé en utilisant des paramètres morphologiques de l'utilisateur en combinaison avec un modèle déterminé de manière empirique.

10. Procédé selon l'une quelconque des revendications 1 à 9, comprenant en outre l'estimation de la fréquence cardiaque a priori de l'utilisateur en utilisant la vitesse instantanée déterminée et un modèle associant une valeur de fréquence cardiaque à la vitesse instantanée.

11. Procédé selon la revendication 10, dans lequel le modèle comprend une relation linéaire ou non linéaire entre la vitesse instantanée déterminée et ladite valeur de la fréquence cardiaque.

12. Procédé selon la revendication 10, dans lequel le modèle comprend un modèle physiologique comprenant un âge, un sexe, un poids ou une taille de l'utilisateur.

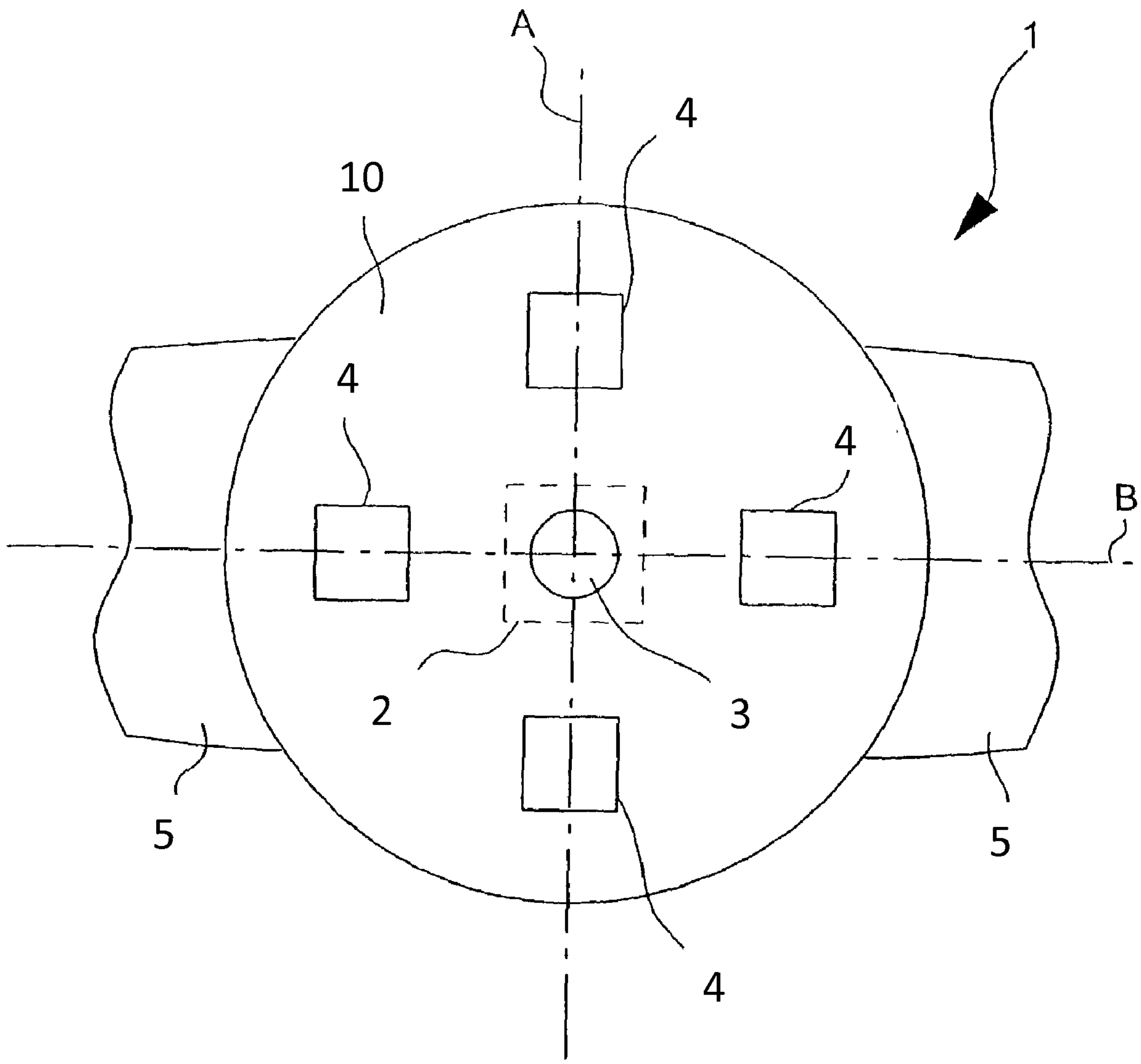
13. Procédé selon l'une quelconque des revendications 10 ou 12, dans lequel le dispositif de détection (1) comprend en outre un capteur de fréquence cardiaque (4, 5) adapté pour mesurer un signal de fréquence cardiaque lorsque le dispositif de détection (1) est porté ; et dans lequel le procédé comprend en outre la mesure du signal de fréquence cardiaque et l'estimation d'une fréquence cardiaque mesurée à partir du signal de fréquence cardiaque mesurée.

14. Procédé selon la revendication 13, dans lequel ladite estimation d'une fréquence cardiaque mesurée comprend la détermination d'une fiabilité de la fréquence cardiaque mesurée ; et dans lequel la fréquence cardiaque a priori est utilisée en combinaison avec la fréquence cardiaque mesurée lorsque la fréquence cardiaque mesurée n'est pas fiable.

15. Procédé selon la revendication 14, comprenant en outre l'adaptation spécifique à l'utilisateur du modèle en utilisant le rythme cardiaque mesuré lorsque le rythme cardiaque mesuré est fiable.

16. Procédé selon l'une quelconque des revendications 1 à 12, comprenant en outre l'estimation de la distance parcourue par l'utilisateur en utilisant l'intégration de la vitesse instantanée déterminée.

17. Procédé selon l'une quelconque des revendications 1 à 13, comprenant en outre le calcul d'une dépense d'énergie de l'utilisateur en utilisant la vitesse instantanée déterminée.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REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	用于确定用户的即时速度和用于改善心率估计的方法		
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其他公开文献	EP2910901A1		
外部链接	[Espacenet]		

摘要(译)

本公开涉及一种用于使用预定佩戴在用户的手臂上的感测装置（1）来确定用户的瞬时速度的方法，并且包括用于测量和传递代表用户的运动信号的运动传感器（2）。佩戴传感装置（1）时的动作;该方法包括：测量运动信号;识别用户何时进行节奏活动并根据测量的运动信号估计用户的基本运动频率;通过使用测量的运动信号和基本运动频率计算用户的活动水平来识别用户何时行走或跑步;当用户行走或跑步时，提供测量的运动信号与与用户步进的推进冲击相关的相应运动特征之间的关系;使用运动特征估计用户步数的频率和用户的用户相对步长;通过组合估计的步进频率和估计的步长来确定用户相对时刻速度;使用校准因子，使用来自用户相对瞬时速度的校准因子，根据用户相对瞬时速度确定瞬时速度。