(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 July 2014 (17.07.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/108883 A1

(51) International Patent Classification:
G06F 3/01 (2006.01) *H04B 1/10* (2006.01)
G06K 7/10 (2006.01)

(21) International Application Number:
PCT/IB2014/058265

(22) International Filing Date:
14 January 2014 (14.01.2014)

(25) Filing Language: Italian

(26) Publication Language: English

(30) Priority Data:
PI2013A000002 14 January 2013 (14.01.2013) IT
PI2013A000003 14 January 2013 (14.01.2013) IT

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,

[Continued on next page]

(54) Title: METHOD AND RELATED APPARATUS FOR MONITORING BIOMECHANICAL PERFORMANCES OF HUMAN LIMBS

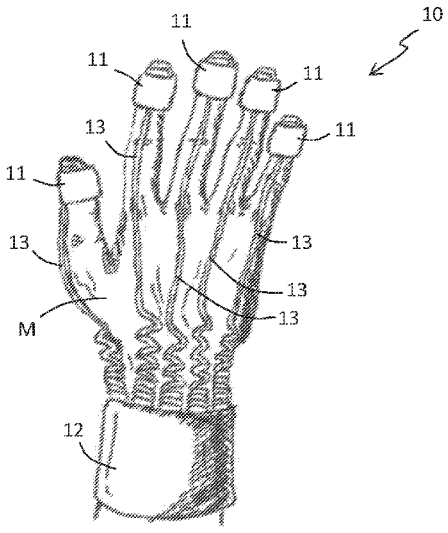

FIG. 1

(57) Abstract: A wearable apparatus with sensors comprises at least a device with sensors for the hand (10) comprising a plurality of sensor units (11) including tri-axial inertial sensors and they can be associated to the distal phalanxes of the fingers, at least a coordinator unit (12) adapted to manage the flow of data acquired by the sensor units and providing memory means and power supply means, and connection means (13) for connecting the sensor units (11) to the coordinator unit (12). Each sensor unit (11) comprises fastening means for binding the sensor unit to the human limb arranged so that each sensor unit is independently associable to a distal phalanx or other portion of the limb. A method for monitoring and/or evaluating the motion performance of the limbs in human subjects uses an apparatus according to the invention by acquiring and processing signal from the sensor to obtain biomechanical parameters of interest and indices in particular of a specific motion action.

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UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

Description

METHOD AND RELATED APPARATUS FOR MONITORING BIOMECHANICAL PERFORMANCES OF HUMAN LIMBS

Technical Field

[1] The present invention concerns a method for the determination of the biomechanical performance of the limbs of human subjects by sensor units associated to the same

[2] The present invention also relates to a wearable apparatus with sensors of the type comprising a plurality of sensor units connected to at least a coordination unit that manages the data from the sensor units and their transmission.

Background Art

[3] In the field of bioengineering great attention is paid to the study of human movement in three-dimensional space under the multiple and potential applications. In fact, the ability to recognize and measure metrics and parameters related to human posture and movement may have technical applications in many areas such as social, occupational, sporting, recreational / leisure, music, health, etc..

[4] As part of the systems for movement analysis particular attention is paid to systems capable of measuring the fine movements of the hand and fingers, in order to assess and recognize those motor actions which man uses to communicate and receive information in a direct and immediate way and to give gestures new types of meaning readily translated into concrete actions.

[5] Today, there are many known types of wearable devices that use sensors of various kinds to measure in real time the movements of a human hand.

[6] For example, in U.S. 2012/0025945 A1 is described a glove for the detection of movement equipped with sensors and wherein each motion detected by the sensors is associated with a time reference so that the data on the movement can be synchronized with the motion data of other similar devices.

[7] U.S. 8,009,141 B1 describes a method and a system for gathering information using the hand. The system is based on the analysis of images acquired by sensors located at the hand and fingers. The system needs to be inserted in a given environmental context that must be a reference for the determination of the movement.

[8] In TW 200931300A is described a device consisting of a glove provided with housings for sensors each of which consists of a gyroscope. Many other devices for detecting the position and movement of a human limb are known and consist of gloves to which are associated sensors of various nature which may be switches, optical detectors, sensors of flexion, accelerometers, optical fiber bending sensors or combinations of the above types of sensors.

[9] All the devices of the prior art have, however, limitations. First, it should be noted

that some types of sensors have specific limitations and drawbacks. For example, the sensors that comprise image detectors require external references and frequent calibrations; flexion sensors are subject to wear and they also have the need to be calibrated frequently.

[10] Furthermore, in all the known devices the sensors are physically connected to each other so that their initial mutual position is predetermined and unchangeable. The above kind of connection exists because the sensors are associated, and more or less integrated, in a glove that facilitates the donning but that involves several drawbacks. First, the ability to properly use the device depends on the physical compliance of the person wearing the device itself and it is therefore necessary to provide different devices of different size. Then, the presence of the glove often generates many artifacts due to movement between the surfaces of the device and the body surfaces. Furthermore, many devices of the known art are integrated in gloves rather bulky, with a certain thickness and a flexibility and elasticity rather limited, whereby the device itself produces alterations of the natural movements of the hand.

[11] In U.S. 2012/0319940 A1 is described a wearable device constituted by a plurality of motion sensors associated independently to the fingers and a processing unit, possibly also comprising motion sensors, associated to the wrist, and also comprising a communication module to communicate with an external electronic device. The apparatus described can be used as an alternative input device instead of a mouse, keyboard, or other and it can recognize the gestures made by the limbs, either predetermined gestures or user-defined gestures.

[12] However, it appears desirable to seek appropriate solutions to exploit the potential of devices such as the one described above in the health sector, and in particular to monitor and assess motor performance of human limbs. In fact, many neurodegenerative diseases result in a degradation of motion abilities, and in particular, of specific motion abilities of the limbs, which is desirable to monitor for diagnostic purposes, to assess the effectiveness of rehabilitative therapy, for statistical studies, and for other purposes too.

Disclosure of Invention Technical Problem

[13] It is an object of the present invention to propose a method for monitoring the movement performance of the limbs in human subjects.

[14] It is another object of the present invention to propose a method that using an apparatus provided with wearable sensors permits the measurement of the movement performance of the limbs of human subjects in order to define and discriminate performance associable to certain pathological conditions.

[15] It is other object of the present invention to propose a wearable sensorized apparatus suitable in particular to assess the motor performance of the limbs in human subjects.

[16] Further and specific object of the present invention is to propose a wearable sensorized apparatus that is not affected by the size and morphology of the user's body.

Technical Solution

[17] According to an aspect of the present invention, the above objects and others are achieved by means of a method as set forth and characterized in the independent claim 1.

[18] The claims dependent on claim 1 describe other characteristics of the present invention or variants to the main inventive idea.

[19] A wearable apparatus with sensors of known type comprises at least a device with sensors for the hand comprising: a plurality of sensor units at least some of them associated to the fingers of the limb and physically connected together in such a way that their home mutual position is substantially determined and immutable; at least one coordinator unit suitable to manage the flow of data acquired by the sensor units and provided with memory means and supply means; and connection means of the sensor units to the coordinator unit suitable for data transmission and power supply of the sensory units.

[20] According to a characteristic feature of the present invention, each sensor unit comprises independent constraint means for constraining the sensor unit to the human limb so that each sensor unit is independently attachable to a portion of the limb.

[21] Advantageously, each sensor unit includes at least one microcontroller and a sensor module consisting of three tri-axial inertial sensors: a tri-axial accelerometer, a tri-axial gyroscope and a tri-axial magnetometer.

[22] Each sensor unit consists of an inertial system with full recognition of nine axes with great advantages of accuracy of measurement compared to the sensor units of the prior art. Furthermore, the components have low cost and have not substantially wear problems since there are no parts subject to deformations as is the case when using sensors of flexion. Finally, the presence of a microcontroller in each sensor unit makes the latter a substantially autonomous module allowing a distributed data processing with high computational efficiency and the possibility of high-frequency data acquisition.

[23] Still advantageously at least three sensor units can be associated to the last phalanx of the fingers, and the coordinator unit is attachable to the forearm and includes a sensor module.

[24] The constraint means for fastening the sensor unit to the portion of the limb thereof are selected from elastic rings, thimbles, silicon or Velcro bands, fasteners, adhesive fastening means.

[25] The above types of constraint means allow an extremely fast and comfortable fastening of the sensor unit.

[26] The connection means of the sensor units to the coordinator unit are wirings with variable length, in particular spiral cables.

[27] This arrangement allows a great freedom when placing the sensor units with reference to the coordinator unit thus making the device universally applicable to limbs of every size and morphology.

[28] Alternatively, the previously mentioned connection means may be of wireless type and in this case, the sensor units and the coordinator unit would be provided with wireless communication modules. In this case, each sensor unit includes electric batteries and wireless communication modules.

[29] According to another aspect of the present invention, the above objects are achieved thanks to a method for monitoring and / or evaluating the movement performance of the limbs in human subjects, performed by means of a wearable apparatus with sensors according to one of the preceding claims. The method of the invention is characterized in that it comprises steps of:

definition of biomechanical parameters of interest for a given motion action,

• activation of sensor units of the said apparatus involved in the motion action of interest;

• acquisition of signals from inertial sensors of said sensor units ,

• filtering of the acquired signal with frequency filters, in order to eliminate the high frequency noise,

• signal processing in the space-time domain using specific threshold algorithms to perform a segmentation of the signal to divide the motion action of interest into elementary steps and determine the typical duration times,

• integration of the signals derived from said inertial sensors and the information derived from such segmentation to calculate said biomechanical parameters of interest.

Advantageous Effects

[30] The method described above allows exploiting the features and capabilities of the apparatus of the invention in particular in the health sector to monitor, evaluate, determine the motion abilities of healthy subjects as well as with specific diseases. A method as outlined can be advantageously applied to monitor the progress of diseases, for diagnostic purposes, to define rehabilitative therapies and for many other purposes.

[31] Furthermore, in a device as outlined above each sensor unit is constrained and referred to the limb in an independent manner with respect to the other sensor units thus making the device not affected by the size and morphology of the limb. Moreover, since each sensor unit is exclusively tied to the body portion (in particular the last phalanges of the fingers) whose position and whose movement must be detected, the evaluation of the motion is not affected by errors due to displacements of the sensor unit on the body portion caused by interactions with

other portions of the limb, as happens when the sensor units are integrated within a glove. Moreover, thanks to the independent constraint means of each sensor unit that not affects the joints the device does not influence in any way the motion abilities allowing the correct evaluation of the latter.

Description of Drawings

[33] These and other features of the invention will become more readily understandable from the following description of preferred embodiments, given as non-limiting examples, with reference to the accompanying drawings in which;
- the Figures 1 and 2 show schematic perspective views of a device according to the present invention applied to a human right hand; and
- Figure 3 shows a block diagram of the electronic components of the device of Figures 1 and 2.

Mode for Invention

[34]

[35] With reference to Figures 1 and 2 a sensorized wearable apparatus according to the present invention comprises, a device with sensors for the hand, indicated overall by 10 and represented in the use configuration worn by a human right hand, M.

[36] The device 10 consists of five sensor units, 11, one for each finger, by a coordinator unit, 12, and by connection means, 13, of each sensor unit with the coordinator unit.

[37] The sensor units 11 are integrated into constraint means for fastening them to the fingers. In the present embodiment, the constraint means are made by elastic rings that are worn on the last phalanx, or distal phalanx, and then positioned therein. Obviously, compared to what is generically represented, the fastening means of the sensor units 11 to the fingers can also be very different. For example, they may have the form of caps to be applied at the end of the finger, or may be in the form of strips of material provided with closure elements formed by hooks, loops, buttons, stickers, or other type. Also from the point of view of materials in which the restraining means are made, there is a possibility of choice rather broad. In fact, they could be made of fabric, silicone or other polymeric material, natural rubber, or more. Obviously, the material of the restraining means may influence both the choice of the fastening elements and the mode the sensor unit is integrated into the fastening means themselves. For example, in the embodiment shown the fastening means are fabric elastic rings tissue in which the constraining element is constituted by the elasticity of the material itself and the electronic components of the sensing device are housed in a pocket formed in the thickness of the ring. In the case that the restraining means are made of silicone,

the electronic components may be incorporated directly in the means of constraint during a forming phase of the same.

[38] The coordinator unit 12 is also provided with constraint means for constraining to the body portion to which it must be bound. In the present embodiment, the coordinator unit is positioned on the forearm, near the wrist and it is then integrated in a wrist strap, a ring of elastic fabric having size suitable to be worn on the wrist, which constitutes the means of constraint. Also with regard to the coordinator unit, the restraining means may be of various types, which may render the coordinator unit itself suitable to be associated to a specific portion of the limb.

[39] In the shown embodiment, the connecting means 13 are constituted by coiled flexible cables through which data transfer takes place from the sensor units to the coordinator unit and the power supply of the sensor units. The spiral configuration of a portion of the cables allows a high variability of the distance between the sensor unit 11 and the coordinator unit 12, thus making the device substantially independent of the size of the limb. The spiral-shaped portion, which is more bulky than the rest of the cable, is placed at the wrist, near the coordinator unit, and therefore does not obstacle the free movement of the hand and fingers. Moreover, the coiled cables 13 provide the typical advantages of wired compared to wireless connections, namely higher amount of data transmitted per unit of time, and increased reliability with less risk of loss of data packets.

[40] According to a different and preferred embodiment, the connection between each sensor unit 11 and the coordinator unit 12 takes place in wireless mode for which the joint movement of the wrist and of each phalanx of each finger is completely free and therefore not altered by the device 10 itself.

[41] In this case, each sensor unit 11 includes a sensor module, 14, a microcontroller, a memory unit, a radio communication module and power supply means including rechargeable electric batteries and a power manager unit.

[42] As clearly derivable from the foregoing description the restraining means in which are integrated the individual sensor units 11 and the connection means with the coordinator unit 12 are peculiarly designed to optimize the wearability of the device and not to affect it in any way the motion abilities of the single joints of the limb. In fact, while the majority of wearable devices with sensors of the prior art are employed to recognize specific motion actions, encoded or encodable, and therefore they can be effective and useful even if they include motion alterations caused by the device itself, the device of the invention being used to study the motion abilities of limbs must not influence them.

[43] With reference to Figure 3 will be described below the device from the electronic point of view.

[44] Each sensor unit 11 comprises a sensor module, 14, and a microcontroller, 15, integrated into constraint means as described above.

[45] Each sensor module 14 includes three tri-axial inertial sensors, more precisely, a tri-axial accelerometer, a tri-axial gyroscope and a tri-axial magnetometer. Thanks

to the presence of the aforementioned types of sensors, each sensor unit is able to collect a full 9-axis information about its position and its movement without the need of external references and frequent calibrations. In addition, the inertial sensors are substantially free from wear and they have very low cost and size. The microcontroller 15 controls the sensor module 14 associated with it.

[46] The coordinator unit 12 comprises a sensor module 14, a microcontroller, 15a, a memory unit 16, a communication module, 17, and power supply means, 18.

[47] The sensor module 14 contained in the coordinator unit 12 is identical to those present in the sensor units 11 and therefore includes three tri-axial inertial sensors. The microcontroller 15a associated with it, in addition to managing their own sensor module has the function of timing and appropriately manage the flow of data from the sensor units 11.

[48] The flow of data from the sensor units 11 to the coordinator unit 12 takes place via the connection means 13 using a standard communication protocol, such as the CAN-bus of the present embodiment, or a proprietary communication protocol, or, as already described, via wireless communication protocols, of a Bluetooth type or other type.

[49] The data collected, and possibly processed in the coordinator unit 12, are advantageously, but not limited to, stored in the memory unit 16, which may for example be a SD-card slot. Alternatively, the data are sent directly to an external computer, C, via a Bluetooth or another wireless communication standard or via a wired connection of the device 10 to the external computer C. Still alternatively, the data collected in the coordinator unit 12 are treated according to a cloud system, and therefore are transmitted via the Internet to a remote server in which are stored and from which they can subsequently be recovered from any other remote terminal also connected to the Internet. In this case, the coordinator unit 12 advantageously comprises a module for the exchange of data on mobile networks, such as those with 3G or 4G standard. The use of a cloud-based system allows to implement services for remote monitoring of motion performance that involve significant advantages such as a greater usability, reduced costs, real-time updating of the data, and others.

[50] The power supply means 18 are constituted by rechargeable batteries of appropriate size and capacity, which can be connected to an external power source, P, and are suitable to feed both the coordinator unit 12 and the sensor units 11 for a reasonable number of hours. Obviously, in the case that the exchange of data between the sensor units and the coordinator unit takes place in wireless mode, each sensor unit 11 is provided with its own electric batteries.

[51] Obviously, the coordinator unit 12 may or may not include sensor modules 14 and it could be dedicated exclusively to the management of data from the sensor units 11.

[52] Moreover, the coordinator unit 12 may be fastened, using suitable constraint means, to different portions of the limb, such as the back of the hand, or, when it

comprises a sensor module 14, it could be associated with one of the distal phalanges in place of a sensor unit 11.

[53] Advantageously, each sensor module 14 includes additional sensors such as force sensors and / or proximity sensors and / or temperature sensors whose data is collected and transmitted similarly to what happens for the inertial sensors.

[54] A wearable apparatus with sensors according to the present invention also comprises a device with sensors for the foot comprising a coordinator unit 12 entirely similar to that present in the device with sensors for the hand 10, that is containing both a sensor unit 14, both modules processing, communication and power supply. Alternatively, a device with sensors for the foot comprises a sensor module 14, a microcontroller 15 and a wireless communication module for transmitting data to a coordinator unit 12 of the device with sensors for the hand 10. Even for the device with sensors for the foot, the electronics is integrated in constraint means such as flexible adhesive means, elastic rings, elastic or inextensible bands with Velcro means or other fasteners suitable to optimize the donning of the device in correspondence of the foot without affecting in any way the motion abilities.

[55] As is the case in the prior art, in the external processing unit, the sensor units 14 are mapped and are imposed at a software level constraints related to the morphology of the limb that allow to reconstruct the limb itself and its movements. With the device of the invention, unlike what occurs in the glove-type devices of the prior art, it is very easy to perform the automatic partitioning of the sensor units in use. If, for example, you want to use only the sensor units associated with thumb, middle finger and index, it is enough not to wear the sensor units 11 that are designed to be placed in a pinkie and ring fingers. These, in the embodiment in which the sensor units are connected to the coordinator unit 12 via wired connection, they will remain hanging from the coordinator unit, or they may be placed in a position that does not comply with the morphological constraints imposed by the software of the external computer, which in this case could be instructed to automatically exclude these sensor units. Obviously, the above operation of partitioning is much easier in the case that the connection means 13 are of the wireless type. For example, according to a preferred embodiment, but not limited to, wireless sensor modules 11 include temperature sensors, which, among other things, provide the consent to activation of sensor module when the detected temperature exceeds a certain threshold. In this way, each sensor module is automatically activated when it is worn and it automatically turns off when it is taken out.

[56] A wearable apparatus with sensors as described above can be used in a particularly advantageous manner, in health sector or similar, to monitor the motion performance of the limbs of a human being, according to the method of the present invention described below by means of a specific, but not limitative, embodiment.

[57] For a given motion action, a series of biomechanical parameters of interest are defined. For example, a motion action of interest is constituted by the repeated tapping of the thumb against the index and in this case are arbitrarily defined as "parameters of interest" the number and frequency of taps, the speed and the amplitude of movement of the index, the speed and amplitude of movement of the thumb. To obtain the above desired biomechanical parameters, a method according to the present invention involves the use of a wearable apparatus with sensors as described above by means of the acquisition and processing of signals of the inertial sensors thereof.

[58] Certain sensor units involved in the motion action of interest are activated and their signal is calibrated.

[59] The signal of the inertial sensors is then acquired and filtered by means of frequency filters, in particular fourth-order low-pass Butterworth filters, in order to eliminate the high frequency noise.

[60] The acquired signal is at first processed to estimate the home position and angle of each sensor unit.

[61] Subsequently, the signal is processed in space-time domain using specific threshold algorithms to perform a segmentation of the signal to have the motion action of interest divided into elementary steps and determine the typical duration times.

[62] Finally, post-processing comprises the integration of data from the three-axis accelerometer, gyroscope and magnetometer and use of information obtained from the previous step to calculate the biomechanical parameters of interest. All biomechanical parameters are calculated from acceleration data and angular rate data.

[63] In addition, further processing in the space-time domain is performed through specific algorithms to compare the calculated biomechanical parameters with reference biomechanical parameters in order to calculate indices of motion performance for the specific motion action.

[64] All the signal-processing steps above specified both for the filtering of the signal and for the calculation of biomechanical parameters and performance indices are advantageously performed directly in the sensor units 11 and in the coordinator unit 12. This allows a reduction of the time needed for the execution of the processing and gives the opportunity to make available information easy to read and interpret in a cloud system. In fact, advantageously, the signals of the inertial sensors and any additional sensors, the biomechanical parameters and performance indexes are sent from the coordinator unit 12 to a cloud server by means of an internet connection implemented thanks to a communication module of the coordinator unit providing 3G or 4G technology.

[65] Advantageously, the method provides for the simultaneous acquisition of signals from the inertial sensors and additional sensors associated with them such as force, proximity and temperature sensors and the signal processing of these

additional sensors to evaluate the sensing capabilities of the subject. Moreover, advantageously, the acquisition of signals from the inertial sensors is conditioned by the signals acquired by the temperature sensor that provides the consent to activation of sensor the module when the detected temperature exceeds a certain threshold value.

[66] Finally, the signals of inertial sensors and additional sensors, biomechanical parameters and performance indices are shown through a graphic user interface on the display means of a remote terminal C, where information are transmitted directly from the processing unit of the wearable device. Alternatively, information can be sent via the Internet to a cloud server and hence can be recovered to be viewed from any remote terminal, even if not equipped with specific software.

[67] Obviously, motion actions of any kind can be defined, from the simplest to the most complex and for each one, according to the method of the invention, certain biomechanical parameters of interest are defined and calculated accordingly. Obviously, depending on the specific motion actions to be monitored not only the biomechanical parameters of interest, but also the methods of filtering and signal processing will change.

[68] Obviously, the above described method of the invention and the apparatus used to carry it out are subject to many further variations, especially in consequence of the specific applications for which they are intended, and the advantages associated with the peculiar features of the method and the apparatus remain unaffected even in the presence of further variations or modifications introduced while always remaining within the scope of protection defined by the following claims.

Claims

1. A wearable apparatus with sensors comprising at least a device with sensors for the hand for detecting the position and movement of a human limb of the type comprising a plurality of sensor units (11) each comprising at least a microcontroller (15) and a sensor module (14) including three tri-axial inertial sensors, wherein at least part of said sensor units can be associated at a limb's fingers, at least a coordinator unit (12) suitable to manage the flow of data acquired by the sensor units and provided with memory means and supply means, and connection means (13) for connecting the sensor units (11) to the coordinator unit (12) suitable for data transmission and power supply of the sensory units, **characterized in that** each sensor unit is associated to independent constraint means for constraining the sensor unit to the human limb so that each sensor unit is independently attachable to a portion of the limb.

2. Apparatus according to claim 1 **characterized in that** said constraint means are selected from: elastic rings, thimbles, silicon or Velcro bands, fasteners, adhesive fastening means or similar means adapted to not affect the motion abilities.

3. Apparatus according to claim 1 **characterized in that** said sensor module (14) comprises a tri-axial accelerometer, a tri-axial gyroscope and a tri-axial magnetometer.

4. Apparatus according to any preceding claim **characterized in that** said sensor module (14) comprises force and / or proximity and / or temperature sensors.

5. Apparatus according to any preceding claim **characterized in that** it comprises at least three sensor units (11) each of which can be independently bound to a fingertip of said limb, said coordinator unit (12) being able to be bound to the forearm of said limb and comprising a sensor module (14).

6. Apparatus according to any preceding claim **characterized in that** said connection means (13) for connecting said sensor unit (11) to said coordinator unit (12) are spiral cables.

7. Apparatus according to any of claims 1 to 5 **characterized in that** said connection means (13) for connecting the sensor units associated to a fingertip (11) to the coordinator unit (12) associated to the wrist are cables comprising at least a spiral portion placed close to the wrist.

8. Apparatus according to any of claims 1 to 5 **characterized in that** said

connection means (13) for connecting said sensor unit (11) to said coordinator unit (12) are of a wireless type.

9. Apparatus according to the previous claim **characterized in that** said sensor units (11) comprise rechargeable power supply means.

10. Apparatus according to claim 8 or 9 **characterized in that** said sensor units (11) comprise a memory unit and a radio communication module.

11. Apparatus according to any preceding claim **characterized in that** it comprises a device with sensors for the foot including a sensor unit (14), a microcontroller (15) and a communication module.

12. Apparatus according to the previous claim **characterized in that** it comprises a coordinator unit (12).

13. Method for monitoring and / or evaluating the movement performance of the limbs in human subjects, performed by means of a wearable apparatus with sensors according to one of the preceding claims, said method being characterized in that it comprises steps of:
• definition of biomechanical parameters of interest for a given motion action,
• activation of sensor units of the said apparatus involved in the motion action of interest;
• acquisition of signals from inertial sensors of said sensor units ,
• filtering of the acquired signal with frequency filters, in order to eliminate the high frequency noise,
• signal processing in the space-time domain using specific threshold algorithms to perform a segmentation of the signal to divide the motion action of interest into elementary steps and determine the typical duration times,
• integration of the signals derived from said inertial sensors and the information derived from such segmentation to calculate said biomechanical parameters of interest.

14. Method according to the previous claim wherein a further processing step in the space-time domain is performed through specific algorithms to compare said calculated biomechanical parameters with reference biomechanical parameters in order to calculate indices of motion performance for the specific motion action

15. Method according to claim 13 or 14 wherein additional signals are acquired from force and / or proximity and / or temperature sensors also comprised in said sensor units, and then processed to evaluate indices of sensing capabilities of the subject.

16. Method according to claim 13 or followings wherein said frequency filters are fourth-order low-pass Butterworth filters.

17. Method according to claim 13 or followings wherein said inertial sensors comprise a tri-axial accelerometer, a tri-axial gyroscope and a tri-axial magnetometer, said step of integration of the signals comprising integrating the signals of each axis of each of said inertial sensors.

18. Method according to claim 13 or followings wherein said inertial sensors are calibrated upon activation.

19. Method according to claim 13 or followings wherein the signals acquired by said inertial sensors are processed to estimate their home position and angle

20. Method according to claim 13 or followings wherein all the biomechanical parameters of interest are calculated from acceleration data and angular rate data obtained from the signals acquired by said inertial sensors.

21. Method according to claim 13 or followings wherein the acquisition of signals from said inertial sensors is conditioned by the signals acquired by a temperature sensor associated to said inertial sensors thereof of a sensor unit that provides the consent to activation of sensor the module when the detected temperature exceeds a certain threshold value.

22. Method according to claim 13 or followings wherein said signals of inertial sensors and additional sensors, biomechanical parameters and performance indices are sent from said coordinator unit (12) to a cloud server, via the Internet thanks to a radio communication module of the coordinator unit (12).

23. Method according to claim 13 or followings wherein said signals of inertial sensors and additional sensors, biomechanical parameters and performance indices are shown through a graphic user interface on the display means of a remote terminal.

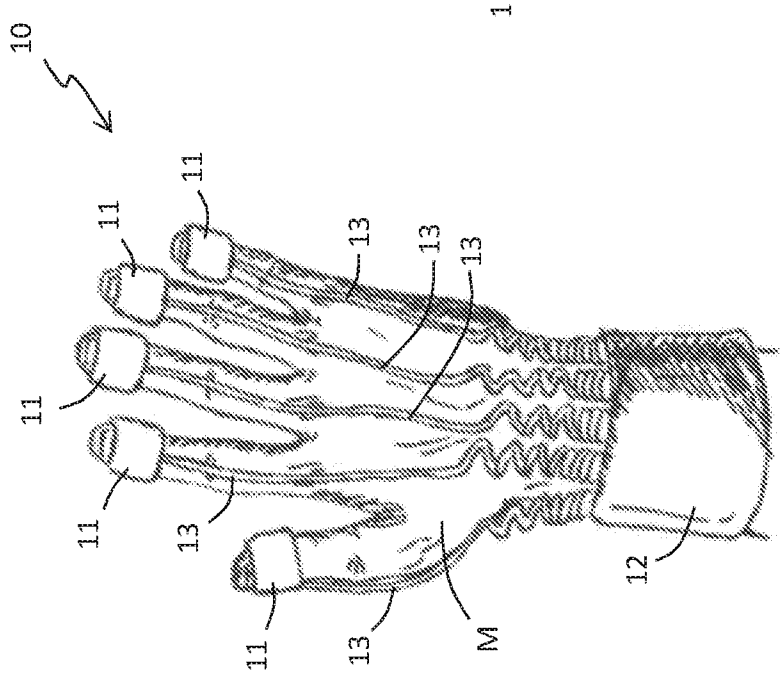

FIG. 1

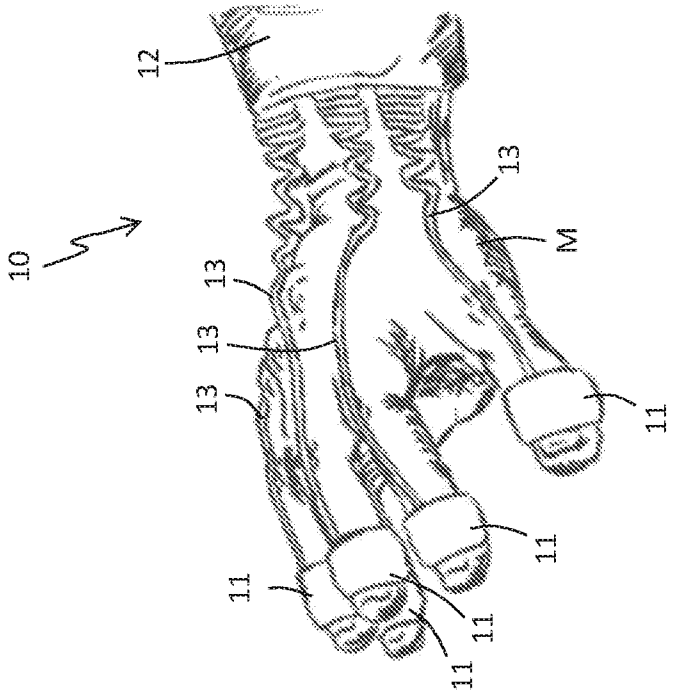

FIG. 2

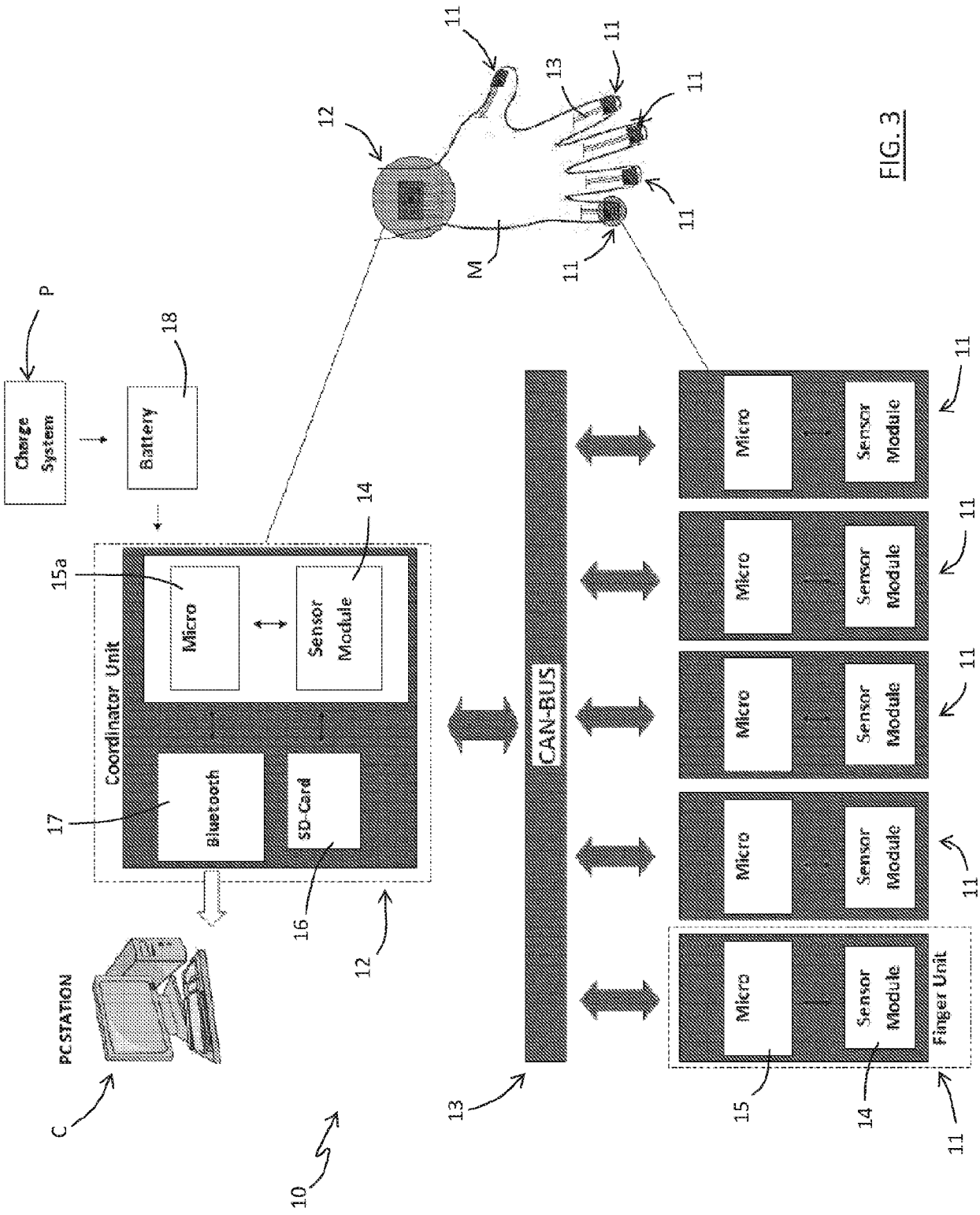
P
Charge System
18
Battery
15a
Micro
Sensor Module
14
Coordinator Unit
17
Bluetooth
SD-Card
16
12
PC STATION
C
10
CAN-BUS
13
11
12
13
M
Micro
Sensor Module
Finger Unit
15
14

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/058265

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F3/01 G06K7/10 H04B1/10
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)
G06F G06K H04B

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.
X	US 2012/319940 A1 (BRESS DANIEL [US] ET AL) 20 December 2012 (2012-12-20) abstract paragraphs [0030] - [0045] paragraphs [0071] - [0075] paragraphs [0078] - [0079] figures 1-3 paragraphs [0119] - [0129] figure 4 paragraphs [0151], [0174] - [0175] ----- -/--	1-23

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 March 2014	04/04/2014

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	De Ceulaer, Bart

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/058265

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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