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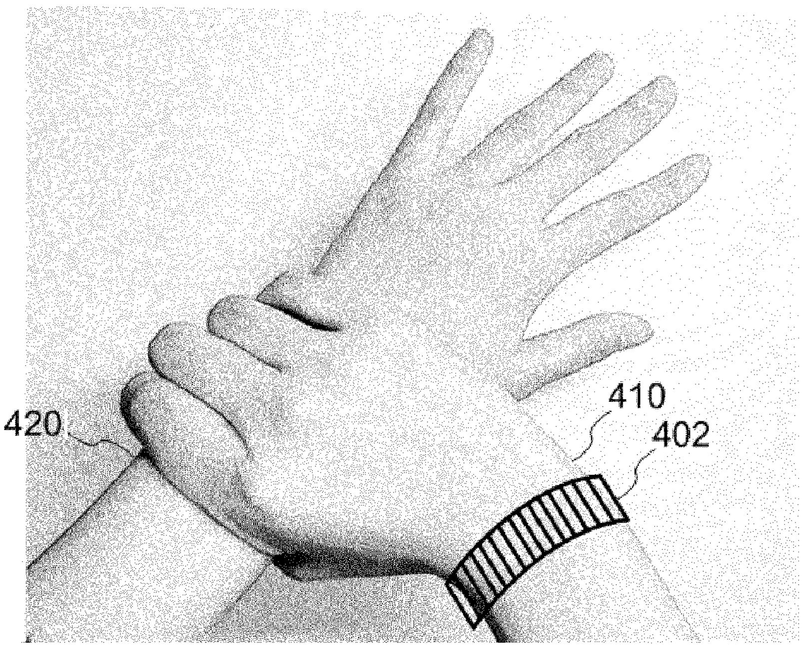

Fig. 4

(57) Abstract: The present disclosure provides a method (100) for adapting a wearable device. The method (100) comprises: sensing (SI 10) an electromyography (EMG) data responsive to a hand gesture of a user; determining (SI 20) a pressure applied in association with the hand gesture based on the EMG data; and causing (SI 30) the wearable device to be adapted to a body part of the user based on the pressure.

WO 2017/125148 A1

METHOD AND APPARATUS FOR ADAPTING WEARABLE DEVICE

TECHNICAL FIELD

The present disclosure relates to wearable devices, and more particularly, to a method and apparatus for adapting a wearable device.

BACKGROUND

Wearable devices are expected to become ubiquitous in people's lives in the future. Future wearable devices will range from smart textiles/clothes and smart watches to handheld devices such as smartphones or tablets. For example, many companies are investing heavily on smart clothes capable of providing users with more suitable fitting and temperature, moisture and other conditions.

Proper adaptation of a wearable device is an important issue such that a user can wear the device in a comfortable manner. For example, a user may wear a smart device (e.g., a smart watch) around his/her wrist and desire to adjust the device such that it can properly fit the wrist. US201 501 16920A1 , provides a method for guiding a user to bend a flexible device in a correct manner by displaying instructions on a screen of the device, so that the device does not break. However, it does not consider the comfort of the user and cannot fit the device to a body part of the user.

There is thus a need for a solution to fit a wearable device to a body part of a user properly.

SUMMARY

It is an object of the present disclosure to provide a method and apparatus for adapting a wearable device, capable of fitting the wearable device to a body part of a user properly and efficiently.

In a first aspect, a method for adapting a wearable device is provided. The method comprises: sensing electromyography (EMG) data responsive to a hand gesture of a user; determining a pressure applied in association with the hand gesture based on the EMG data; and causing the wearable device to be adapted to a body part of the user based on the pressure.

In an embodiment, the hand gesture is associated with at least two digits of a hand of the user.

In an embodiment, the EMG data represents a level of pressure applied by each of the at least two digits.

In an embodiment, the step of determining comprises: calculating the pressure based on the levels of pressures applied by the at least two digits.

In an embodiment, the step of causing comprises: causing one or more actuators arranged in the wearable device to adjust fitting of the wearable device to the body part based on the pressure.

In an embodiment, the one or more actuators cause the wearable device to extend or contract based on the pressure.

In an embodiment, the body part comprises a wrist corresponding to the hand of the user.

In a second aspect, an apparatus for adapting a wearable device is provided. The apparatus comprises: an electromyography (EMG) sensor configured to sense an EMG data responsive to a hand gesture of a user; and a processor configured to: determine a pressure applied in association with the hand gesture based on the EMG data; and cause the wearable device to be adapted to a body part of the user based on the pressure.

In an embodiment, the hand gesture is associated with at least two digits of a hand of the user.

In an embodiment, the EMG data represents a level of pressure applied by each of the at least two digits.

In an embodiment, the processor is configured to calculate the pressure based on the levels of pressures applied by the at least two digits.

In an embodiment, the processor is configured to cause one or more actuators arranged in the wearable device to adjust fitting of the wearable device to the body part based on the pressure.

In an embodiment, the one or more actuators cause the wearable device to extend or contract based on the pressure.

In an embodiment, the body part comprises a wrist corresponding to the hand of the user.

In a third aspect, a wearable device is provided. The wearable device comprises: an apparatus for adapting the wearable device according to the above second aspect; and one or more actuators configured to adjust fitting of the wearable device to the body part.

With the embodiments of the present disclosure, an EMG data responsive to a hand gesture of a user can be sensed and, based on the EMG data, a pressure applied in association with the hand gesture can be determined. Then, a wearable device can be adapted to a body part of the user based on the pressure. In this way, it is possible to fit the wearable device to the user's body part (e.g., wrist) in response to the hand gesture, which enables the user to adjust the fitting of the wearable device efficiently and conveniently.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages will be more apparent from the following description of embodiments with reference to the figures, in which:

Fig. 1 is a flowchart illustrating a method for adapting a wearable device according to an embodiment of the present disclosure;

Fig. 2 is a schematic diagram showing an exemplary structure of a wearable device according to an embodiment of the present disclosure;

Fig. 3 is a schematic diagram showing an equivalent structure of the wearable device of Fig. 2;

Fig. 4 is a schematic diagram showing an exemplary scenario in which the present disclosure can be applied;

Fig. 5 is a block diagram of an apparatus for adapting a wearable device according to an embodiment of the present disclosure; and

Fig. 6 is a block diagram of a wearable device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

The embodiments of the disclosure will be detailed below with reference to the drawings. It should be noted that the following embodiments are illustrative only, rather than limiting the scope of the disclosure.

Fig. 1 is a flowchart illustrating a method 100 for adapting a wearable device according to an embodiment of the present disclosure. The method 100 includes the following steps.

At step S110, an electromyography (EMG) data responsive to a hand gesture of a user is sensed, e.g., by using an EMG sensor. The EMG sensor can measure electrical potentials generated by activities of muscle cells. The EMG sensor may include a number of sensor elements that are carefully placed according to detailed knowledge of the human physiology. Specific muscle activities are measured and used to infer movements. For example, to contract a muscle, the brain sends an electrical signal through the nervous system to motor neurons, which in turn transmit electrical impulses to adjoining muscle fibers, causing the muscle fibers to contract. Many motor neurons and their muscle fibers make up a muscle. During muscle contraction, some subset of these neurons and muscle fibers are activated and the sum of their electrical activity during contraction can be measured with the EMG sensor. The EMG sensor can measure muscular electrical signals from the surface of the skin. For details of the EMG sensor and EMG technique, reference can be made to US20090327171A1 and T. Scott Saponas, et al., *Demonstrating the Feasibility of Using Forearm Electromyography for Muscle-Computer Interfaces,* which is available at http://research.microsoft.com/pubs/64269/chi2008-emg.pdf.

In an example, the hand gesture is associated with at least two digits of a hand of the user. The term "digit" as used herein may refer to a thumb or a finger. For example, the hand gesture can be made by the thumb and the index finger of the hand. Alternatively, the hand gesture can be made by the thumb, the index finger and the middle finger. As another example, the hand gesture can be made by the thumb and all the four fingers of the hand. As yet another example, the hand gesture can be made by two or more fingers of the hand, without involving the thumb. In other words, the hand gesture may include a number of possible digit combinations. The EMG sensor can detect the respective positions of the digits and also a level of pressure applied by each of the digits. That is, the EMG data can represent a level of pressure applied by each of the digits.

At step S120, a pressure applied in association with the hand gesture is determined based on the EMG data.

Without loss of generality, assuming that the hand gesture is made by the thumb and the index finger for example, and the levels of pressures applied by the thumb and the index finger are denoted as P0 and P1, respectively, the pressure, P, applied in association with the hand gesture can be calculated as:

$$P=f(P0, P1) \quad (1)$$

where f() is a predefined or user-specific function. For example, the function f() can be a simple linear function such that P = P0 + P1. Alternatively, the function f() can be a non-linear function such that e.g., P = P0 + P1*2, since the thumb is typically stronger and less sensitive than any finger.

At step S130, the wearable device is caused to be adapted to a body part of the user based on the pressure P. For example, the body part can be a wrist corresponding to the hand of the user.

In an example, one or more actuators arranged in the wearable device can be caused to adjust fitting of the wearable device to the body part based on the pressure P. In particular, the one or more actuators cause the wearable device to extend or contract based on the pressure P.

Fig. 2 is a schematic diagram showing an exemplary structure of a wearable device 200 according to an embodiment of the present disclosure. In this example, the device 200 is a band that can be worn around a wrist of a user and only a segment of the band is shown in Fig. 2 for the purpose of illustration. The device 200 includes a number of joints, some of which are indicated as 202, 204 and 206, and a number of sections, some of which are indicated as 212, 214 and 216. The joints are controlled by one or more actuators (not shown). Each section is made of a flexible material that can extend or contract by a certain magnitude.

Fig. 3 is a schematic diagram showing an equivalent structure of the wearable device of Fig. 2. In Fig. 3, the joints 202, 204 and 206 control spring gains of the sections 212, 214 and 216, respectively. By adjusting the spring gains, the sections can extend or contract, which in turn allows the band to extend or contract accordingly. Here it is assumed that the spring gains of the sections 212, 214 and 216 are the same, denoted as K where $0 \leqslant K \leqslant 1$, for simplicity. Then, K can be determined as:

$$K=L^{*}P \qquad (2)$$

where L is a predefined constant value.

It can be appreciated by those skilled in the art that the above structure shown in Figs. 2 and 3 are illustrative only. The above adjustment capabilities are available through actuators such as electro-active polymers, shape memory alloys, pneumatic pouches, and other soft actuators. For example, a shape memory alloy-based fabric that can extend, bend and contract is described in Yuen, Michelle, et al., *Conformable Actuation and Sensing with Robotic Fabric,* Intelligent Robots and Systems (IROS 2014), 2014 IEEE/RSJ International Conference on. IEEE, 2014.

Fig. 4 is a schematic diagram showing an exemplary scenario in which the present disclosure can be applied. As shown in Fig. 4, a wearable device 402 (a band in this example) is worn around one wrist 410 of a user. The wearable device 402 is equipped with an EMG sensor (not shown). When the user wants to adjust the fitting of the device 402 to the wrist 410, he/she can make a particular hand gesture, e.g., by using his/her thumb and four fingers of a hand corresponding to the wrist 410 to wrap around the other wrist 420 and applying to the wrist 420 a certain force dependent on how loose or tight he/she wants the device 402 to wrap around the wrist 410. The EMG sensor can sense an EMG data representing levels of pressures applied by the five digits, respectively. Based on the EMG data, a pressure applied in association with the hand gesture can be determined. Then, actuators in the device 402 can cause the device 402 to extend or contract based on the pressure. In this way, the user can adjust the fitting of the device 402 to the wrist 410 as desired in an efficient and convenient way.

It is to be noted here that, in the above example, the EMG sensor is provided in the wearable device. That is, the wearable device the user wants to adjust happens to be the device in which the EMG sensor is provided. However, the present disclosure is not limited to this. In another example, the EMG sensor can be provided in a band (e.g., the band 402 as shown in Fig. 4) and the wearable device the user wants to adjust can be e.g., a smart shirt he/she wears. In this case, the band may be equipped with a transmitter for transmitting an adjustment instruction to the smart shirt to cause the smart shirt to extend or contract in response to the user's hand gesture.

Fig. 5 is a block diagram of an apparatus 500 for adapting a wearable device according to an embodiment of the present disclosure. As stated above, the apparatus 500 can be provided within, or separately from, the wearable device.

The apparatus 500 includes an EMG sensor 510 configured to sense an EMG data responsive to a hand gesture of a user.

The apparatus 500 further includes a processor 520 configured to determine a pressure applied in association with the hand gesture based on the EMG data; and cause the wearable device to be adapted to a body part of the user based on the pressure.

In an example, the hand gesture can be associated with at least two digits of a hand of the user.

In an example, the EMG data can represent a level of pressure applied by each of the at least two digits.

In an example, the processor 520 can be configured to calculate the pressure based on the levels of pressures applied by the at least two digits.

In an example, the processor 520 can be configured to cause one or more actuators arranged in the wearable device to adjust fitting of the wearable device to the body part based on the pressure.

In an example, the one or more actuators can cause the wearable device to extend or contract based on the pressure.

In an example, the body part can be a wrist corresponding to the hand of the user.

Fig. 6 is a block diagram of a wearable device 600 according to an embodiment of the present disclosure.

The wearable device 600 includes an EMG sensor 510 and a processor 520 as described above in connection with Fig. 5. The wearable device 600 further includes one or more actuators 630 configured to adjust fitting of the wearable device 600 to the body part.

The present disclosure also provides at least one computer program product in the form of a non-volatile or volatile memory, *e.g.,* an Electrically Erasable Programmable Read-Only Memory (EEPROM), a flash memory and a hard drive. The computer program product includes a computer program. The computer program includes: code/computer readable instructions, which when executed by the processor 520 causes the apparatus 500 to perform the actions, *e.g.,* of the procedure described earlier in conjunction with Fig. 1.

The computer program product may be configured as a computer program code structured in computer program modules. The computer program modules could essentially perform the actions of the flow illustrated in Fig. 1.

The processor may be a single CPU (Central processing unit), but could also comprise two or more processing units. For example, the processor may include general purpose microprocessors; instruction set processors and/or related chips sets and/or special purpose microprocessors such as Application Specific Integrated Circuit (ASICs). The processor may also comprise board memory for caching purposes. The computer program may be carried by a computer program product connected to the processor. The computer program product may comprise a computer readable medium on which the computer program is stored.

For example, the computer program product may be a flash memory, a Random-access memory (RAM), a Read-Only Memory (ROM), or an EEPROM, and the computer program modules described above could in alternative embodiments be distributed on different computer program products in the form of memories.

The disclosure has been described above with reference to embodiments thereof. It should be understood that various modifications, alternations and additions can be made by those skilled in the art without departing from the spirits and scope of the disclosure. Therefore, the scope of the disclosure is not limited to the above particular embodiments but only defined by the claims as attached.

CLAIMS

1. A method (100) for adapting a wearable device, comprising:
   - sensing (S1 10) an electromyography (EMG) data responsive to a hand gesture of a user;
   - determining (S1 20) a pressure applied in association with the hand gesture based on the EMG data; and
   - causing (S1 30) the wearable device to be adapted to a body part of the user based on the pressure.

2. The method (100) of claim 1, wherein the hand gesture is associated with at least two digits of a hand of the user.

3. The method (100) of claim 2, the EMG data represents a level of pressure applied by each of the at least two digits.

4. The method (100) of claim 3, wherein said determining (S1 20) comprises: calculating the pressure based on the levels of pressures applied by the at least two digits.

5. The method (100) of any of claims 1-4, wherein said causing (S1 30) comprises: causing one or more actuators arranged in the wearable device to adjust fitting of the wearable device to the body part based on the pressure.

6. The method (100) of claim 5, wherein the one or more actuators cause the wearable device to extend or contract based on the pressure.

7. The method (100) of any of claims 1-6, wherein the body part comprises a wrist corresponding to the hand of the user.

8. An apparatus (500) for adapting a wearable device, comprising:
   - an electromyography (EMG) sensor (51 0) configured to sense an EMG data responsive to a hand gesture of a user; and

- a processor (520) configured to
  -- determine a pressure applied in association with the hand gesture based on the EMG data; and
  - cause the wearable device to be adapted to a body part of the user based on the pressure.

9. The apparatus (500) of claim 8, wherein the hand gesture is associated with at least two digits of a hand of the user.

10. The apparatus (500) of claim 9, the EMG data represents a level of pressure applied by each of the at least two digits.

11. The apparatus (500) of claim 10, wherein the processor (520) is configured to calculate the pressure based on the levels of pressures applied by the at least two digits.

12. The apparatus (500) of any of claims 8-1 1, wherein the processor (520) is configured to cause one or more actuators arranged in the wearable device to adjust fitting of the wearable device to the body part based on the pressure.

13. The apparatus (500) of claim 12, wherein the one or more actuators cause the wearable device to extend or contract based on the pressure.

14. The apparatus (500) of any of claims 8-1 3, wherein the body part comprises a wrist corresponding to the hand of the user.

15. A wearable (600) device, comprising:

- an apparatus (500) for adapting the wearable device according to any of claims 8-14; and
- one or more actuators (630) configured to adjust fitting of the wearable device to the body part.

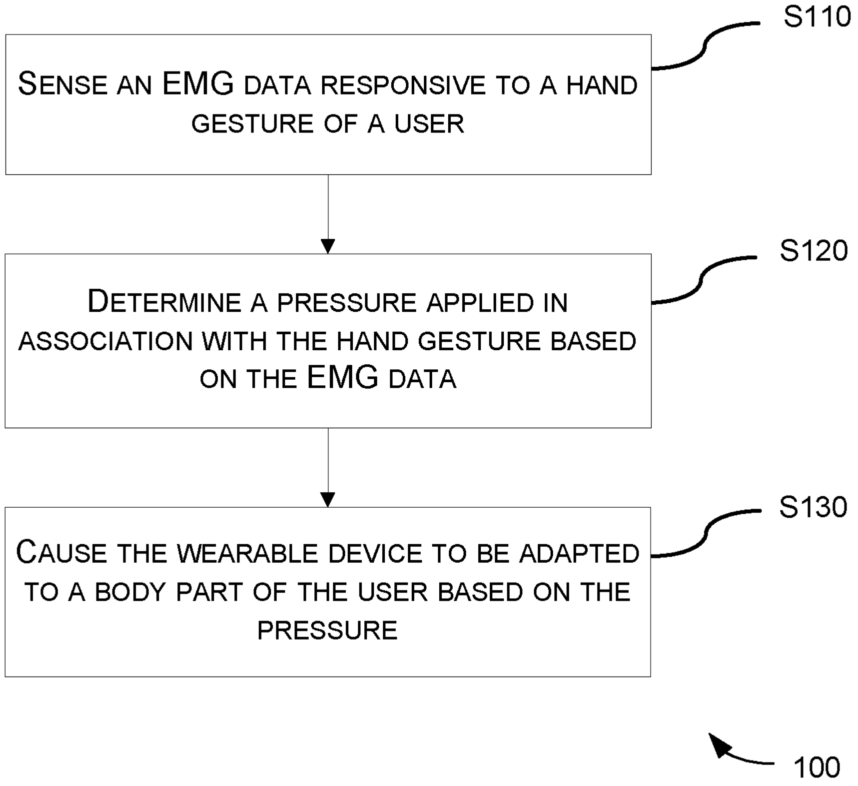
SENSE AN EMG DATA RESPONSIVE TO A HAND GESTURE OF A USER
S110
DETERMINE A PRESSURE APPLIED IN ASSOCIATION WITH THE HAND GESTURE BASED ON THE EMG DATA
S120
CAUSE THE WEARABLE DEVICE TO BE ADAPTED TO A BODY PART OF THE USER BASED ON THE PRESSURE
S130
100

Fig. 1

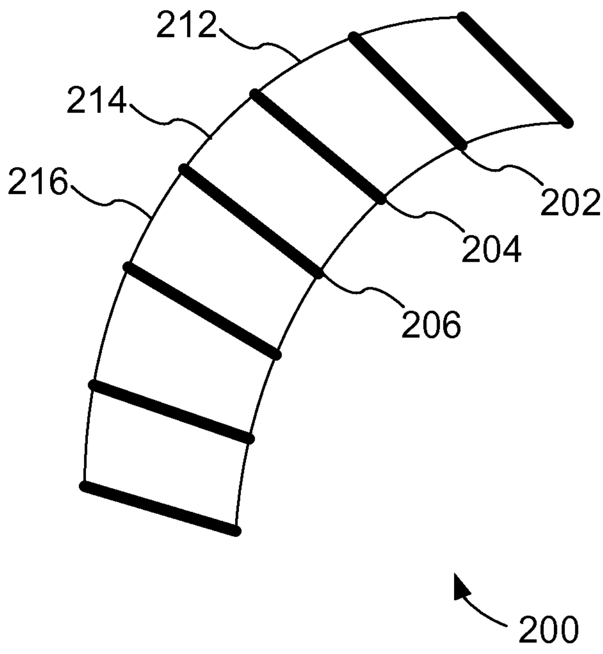
212
214
216
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Fig. 2

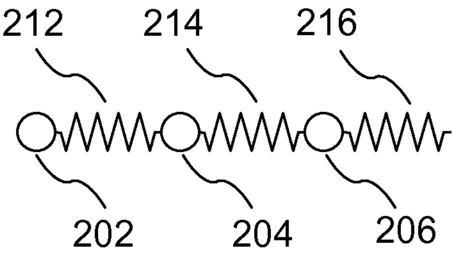

Fig. 3

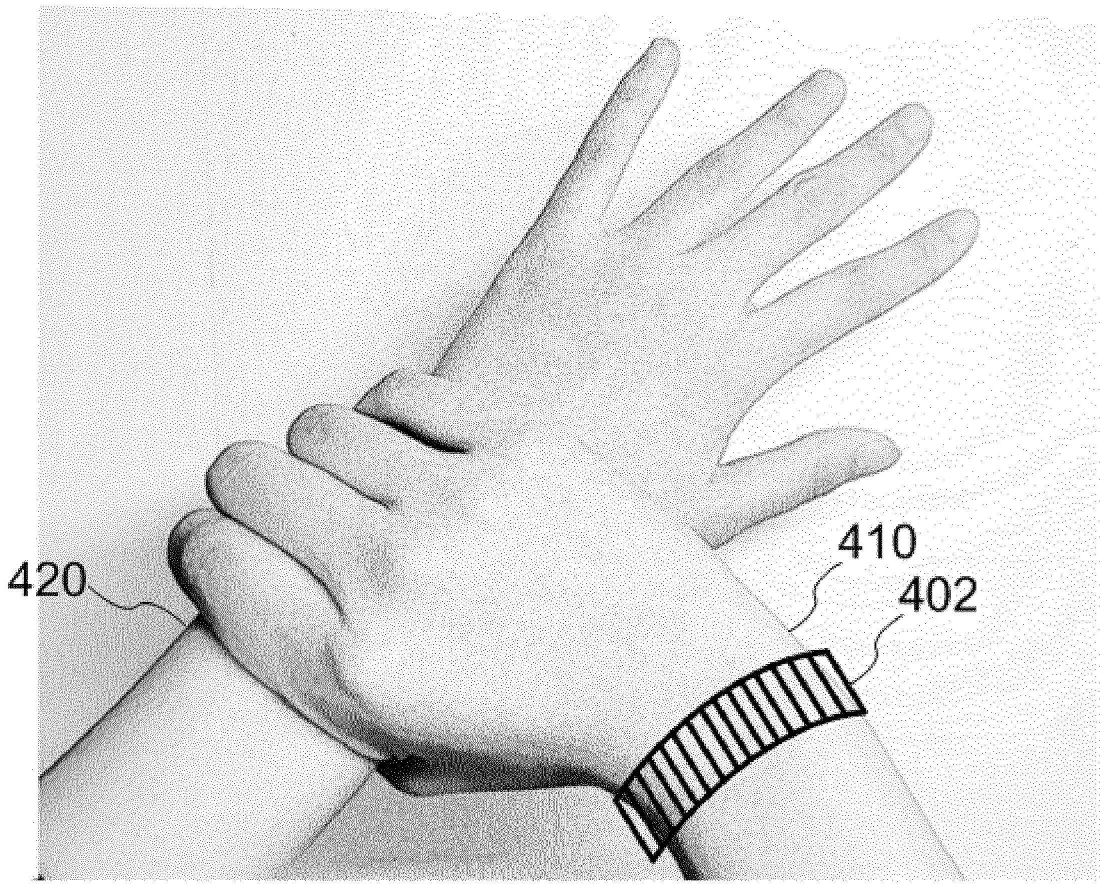

Fig. 4

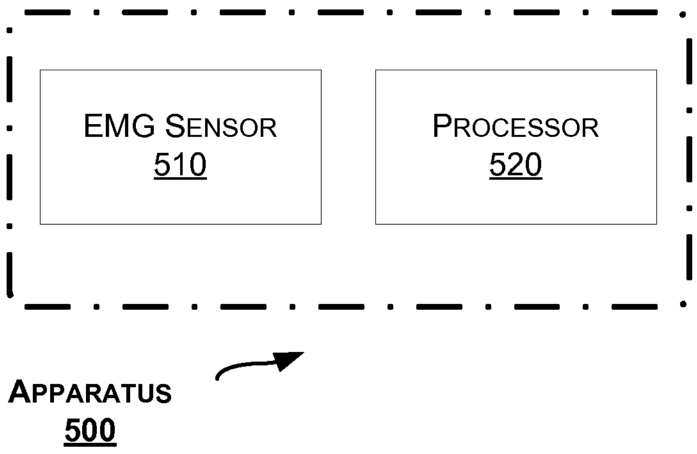
EMG SENSOR
510
PROCESSOR
520
APPARATUS
500

Fig. 5

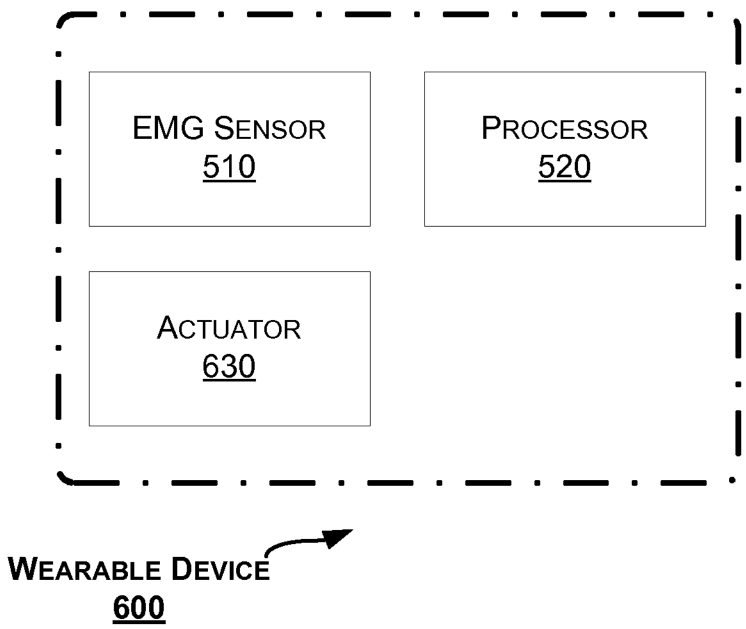
EMG SENSOR
510
PROCESSOR
520
ACTUATOR
630
WEARABLE DEVICE
600

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/051119

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F3/01
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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/073319 Al (HOLSCHUH BRADLEY T [US] ET AL) 12 March 2015 (2015-03-12) paragraphs [0004], [0046], [0052]; figure 3	1-15
A	US 2009/327171 Al (TAN DESNEY [US] ET AL) 31 December 2009 (2009-12-31) cited in the application abstract paragraph [0042] - paragraph [0052]	1-15

-/-

[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

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"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
7 September 2016	14/09/2016

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	Cohen, Benjamin

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SIMONE BENATTI ET AL: "Towards EMG control interface for smart garments", WEARABLE COMPUTERS, ACM, 2 PENN PLAZA, SUITE 701 NEW YORK NY 10121-0701 USA, 13 September 2014 (2014-09-13), pages 163-170, XP058055622, DOI: 10.1145/2641248.2641352 ISBN: 978-1-4503-3048-0 abstract page 165, right-hand column, paragraph 1 -----	1-15
A	US 2010/197184 A1 (BROWNE ALAN L [US] ET AL) 5 August 2010 (2010-08-05) paragraph [0036] - paragraph [0042] -----	1-15
A	CHENAL THOMAS P ET AL: "Variable stiffness fabrics with embedded shape memory materials for wearable applications", 2014 IEEE/RSJ INTERNATIONAL CONFERENCE ON INTELLIGENT ROBOTS AND SYSTEMS, IEEE, 14 September 2014 (2014-09-14), pages 2827-2831, XP032676960, DOI: 10.1109/IROS.2014.6942950 [retrieved on 2014-10-31] abstract -----	1-15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/051119

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US 2010197184 A1	05-08-2010	NONE	