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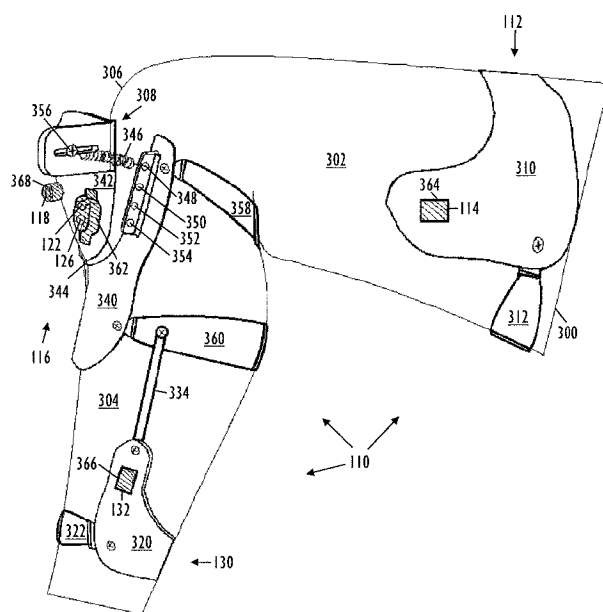


FIG. 3

(57) Abstract: An arrangement (100) for knee diagnostics comprising a measurement apparatus (110) attachable to a leg, and a processing apparatus (140). The measurement apparatus (110) comprises three frames (112, 116, 130) with various sensors: audio sensors (124, 126), thermal sensors (120, 122), and inertial sensors (114, 132). The processing apparatus (140) is caused to: analyze (202) the medial sound and the lateral sound to produce an assessment (204) of a joint friction of the knee; analyze (206) the thigh inertial data and the lower leg inertial data to produce an assessment (208) of a malalignment of the knee; analyze (210) the medial temperature and the lateral temperature to produce an assessment (212) of an inflammation of the knee; and compile (214) an assessment (216) of a condition of the knee (306) based on said assessments (204, 208, 212).



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Arrangement for knee diagnostics

Field

The invention relates to an arrangement for knee diagnostics.

Background

5 The knee joint can be affected by several conditions severely reducing its mobility or even leading to working disability. Common pathologic conditions affecting the knee joint are osteoarthritis and other traumatic- or inflammatory-related diseases inducing deterioration of the joint. The most common one of these conditions is knee osteoarthritis (OA) affecting approximately 10 % of population.
10 Knee OA involves multiple doctor appointments and expensive imaging examinations, often in specialized healthcare, due to its challenging diagnosis. For more information on osteoarthritis, see the following, incorporated herein by reference: Altman RD (1987). Overview of osteoarthritis. *Am J Med.* 83: 65-69. For more information on diagnosis, see the following, incorporated herein by
15 reference: Gunther KP, Sun Y (1999). Reliability of radiographic assessment in hip and knee osteoarthritis. *Osteoarthritis and Cartilage* 7: 239-46.

This complex disorder has been long recognized as a major public health problem: in addition to the deterioration of the quality of individuals' life, it generates significant costs to society. First clinical symptoms of knee OA include
20 pain during joint movement, e.g., when running or walking in stairs. Subsequently, when the disease gets worse, pain will occur also during rest and the knee mobility will be significantly reduced. At the final stage, pain is intolerable and the knee mobility is highly limited, making survival of routine daily activities highly difficult. The only treatment at this stage is the complete knee replacement surgery, which
25 is major and relatively expensive operation requiring specialized healthcare.

While complete pharmaceutical cure of knee OA does not currently exist, the progression of the disease could be hindered by an early stage diagnosis. Similarly to knee OA, the diagnostics of other knee conditions suffers comparable issues due to their subjective assessment and can also lead to knee OA if not treated
30 properly, see the following, incorporated herein by reference: Culvenor AG,

Crossley KM (2016). Accelerated return to sport after anterior cruciate ligament injury: a risk factor for early knee osteoarthritis? Br J Sports Med. 50(5):260-1.

The primary drawbacks of current clinical diagnostics of knee conditions are: time to get the final diagnosis can be long, both direct and indirect costs related to non-diagnosed knee conditions are high, and false detection allows the knee joint to deteriorate further.

Eventually, a late diagnosis of knee OA reduces the available treatment options. On the other hand, for other knee conditions, a late diagnostics often cause the apparition to OA. From an economic point of view, alternative low-cost solutions could replace some unnecessary and expensive clinical examinations at the specialized healthcare related to knee diagnostics.

At the moment, the assessment of knee conditions in the primary healthcare is performed using clinical (physical) examination, X-ray imaging and assessment of symptoms (pain and limited joint movement). However, it is often difficult for a general practitioner to provide an objective and accurate diagnosis due to the insensitivity of clinical examination and X-ray imaging to tissue changes, especially in the case of soft tissues (ligaments, articular cartilage, menisci). Consequently, a patient with knee complaints is quite often referred to a specialized healthcare unit where more comprehensive evaluation of the knee joint is possible, e.g., by using magnetic resonance imaging (MRI) or invasive knee arthroscopy.

In summary, at the moment, accurate diagnosis of early knee OA is not possible at the primary healthcare as it requires advanced techniques, i.e. expensive MRI or invasive arthroscopy, which are not available and are typically performed at a later stage of the disease at the specialized healthcare.

US 2016/0015280 discloses epidermal electronics to monitor repetitive stress injuries and arthritis, but without any specific frame structures.

US 2013/0211259 discloses determination of joint condition based on vibration analysis, disclosing a two-part brace limiting the knee movement.

Brief description

The present invention seeks to provide an improved arrangement for knee diagnostics.

According to an aspect of the present invention, there is provided an
5 arrangement as specified in claim 1.

According to another aspect of the present invention, there is provided a measurement apparatus as specified in claim 17.

According to another aspect of the present invention, there is provided a processing apparatus as specified in claim 18.

10 The present invention may provide the advantage of providing knee diagnostics in a non-invasive manner with a multi-modal data analysis. The present invention may allow to perform low-cost, comprehensive and efficient early knee OA diagnostics already at the primary healthcare. Furthermore, the present invention may allow to diagnose other knee conditions as well, such as anterior
15 cruciate ligament (ACL) injury.

List of drawings

Example embodiments of the present invention are described below, by way of example only, with reference to the accompanying drawings, in which

Figure 1 illustrates example embodiments of an arrangement for knee
20 diagnostics comprising a measurement apparatus attachable to a leg, and a processing apparatus communicatively coupleable with the measurement apparatus;

Figure 2 is a flow chart illustrating example embodiments of processing in the processing apparatus;

25 Figure 3 illustrates example embodiments of the measurement apparatus comprising a first frame, a second frame, and a third frame;

Figure 4 illustrates example embodiments of the second frame;

Figure 5 illustrates example embodiments of the third frame;

Figure 6 illustrates example embodiments of the first frame; and

30 Figures 7, 8 and 9 illustrates example embodiments of sensor frames.

Description of embodiments

The following embodiments are only examples. Although the specification may refer to "an" embodiment in several locations, this does not necessarily mean that each such reference is to the same embodiment(s), or that
5 the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments. Furthermore, words "comprising" and "including" should be understood as not limiting the described embodiments to consist of only those features that have been mentioned and such embodiments may contain also features/structures that have not been
10 specifically mentioned.

Figure 1 illustrates example embodiments of an arrangement 100 for knee diagnostics comprising a measurement apparatus 110 attachable to a leg 300, and a processing apparatus 140 communicatively couplable 160 with the measurement apparatus 110.

15 In an example embodiment, the processing apparatus 140 is a computing device. It may be portable, mobile or stationary. A non-limiting list of example embodiments of the processing apparatus 140 comprises: a computer, a portable computer, a laptop, a mobile phone, a smartphone, a tablet computer, a smartwatch, smartglasses, or any other portable/mobile/stationary computing
20 device, which may output knee diagnosis with a user interface 150.

In an example embodiment, the processing apparatus 140 is a computing server. It may be implemented with any applicable technology. It may include one or more centralized computing apparatuses, or it may include more than one distributed computing apparatuses. It may be implemented with client-
25 server technology, or in a cloud computing environment, or with another technology applicable to the processing apparatus 140 capable of communicating 160 with the measurement apparatus 110.

In an example embodiment, the arrangement 100 may be an independent integrated apparatus comprising as its parts the measurement
30 apparatus 110 and the processing apparatus 140.

In an example embodiment, the arrangement 100 is sold as a product in itself, or the arrangement 100 is marketed as a service per use of the device (the analysis of the signal is performed remotely and the results are sent back to the customer).

5 In an example embodiment, different customers are considered for the arrangement 100:

1) The primary healthcare (both public and private). At the public healthcare, the apparatus 110 and service 140 is used already in the health centres and the test itself is supervised by a nurse or other trained person. At the private
10 healthcare, big health clinics as well as private physiotherapists are the first targeted customers. The arrangement 100 provides a complementary source of information to the practitioner for the diagnosis of early and middle stage knee OA. The easy access to this information already at the primary healthcare prevents extra expenses related to unnecessary advanced examinations and doctor
15 appointments at the specialized healthcare.

2) Sports centres to assess the quality of the knee of athletes.

3) Companies developing orthopaedic devices to validate the design of their product from follow-up populations.

4) Personal users who desire to know the state of their knee.

20 In an example embodiment, the user interface 150 implements the exchange of graphical, textual and/or auditory information relating to knee diagnostics with the user. The user interface 150 may be realized with various techniques, such as a (multi-touch) display, means for producing sound (such as loudspeaker or earpiece), a keyboard, and/or a keypad, for example. The
25 keyboard/keypad may comprise a complete (QWERTY) keyboard, or only a few push buttons and/or rotary buttons. In addition, or alternatively, the user interface 150 may comprise other user interface components, for example various means for focusing a cursor (mouse, track ball, arrow keys, touch sensitive area etc.) or elements enabling audio control.

In an example embodiment, the communication between the measurement apparatus 110 and the processing apparatus 140 may be implemented with wired and/or wireless communication technologies.

Figure 2 illustrates example embodiments of processing in the
5 processing apparatus 140.

Figure 3 illustrates example embodiments of the measurement apparatus 110 comprising a first frame 116, a second frame 112, and a third frame 130.

In an example embodiment, the frames 112, 116, 130 are made of
10 suitable material, such as metal, plastics, and/or composite.

In an example embodiment, the frames 112, 116, 130 are made of 3D printed material and covered by a specific tissue commonly used in orthopaedic industry for the patient comfort. Some aluminium may be added in some parts of the frames 112, 116, 130 to increase its strength and decrease its fragility.

In an example embodiment, all sensors 114, 118, 120, 122, 124, 126,
15 132 may be embedded in printed frames, which may be changed very easily by placing them in a sensor frame 362, 364, 366, 368, 610 couplable with the frames 112, 116, 130.

One benefit of having the frames 112, 116, 130 compared to some other
20 studies using either tapes or just straps is that the locations of the sensors 114, 118, 120, 122, 124, 126, 132 is quite reproducible not only between nurses who might put it on patients, but also anatomically between patients. In an example embodiment, a coupling 334 connecting the first frame 116 and the second frame 130 maintains the distance between the frames 116, 130.

In an example embodiment, the measurement apparatus 110 further
25 comprises a transmitter 134 to communicatively couple 160 the measurement apparatus 110 with the processing apparatus 140.

In an example embodiment, the processing apparatus 110 also
30 comprises a receiver (or a transceiver) to communicatively couple 160 the measurement apparatus 110 with the processing apparatus 140.

In an example embodiment, the coupling 160 is wired, employing suitable standard or proprietary bus and protocol. In an example embodiment, the coupling 160 is wireless employing a radio transmitter. In an example embodiment, the radio transmitter is a part of a radio transceiver. In an example embodiment, the radio transceiver comprises a cellular radio transceiver (communicating with technologies such as GSM, GPRS, EGPRS, WCDMA, UMTS, 3GPP, IMT, LTE, LTE-A, etc.) and/or a non-cellular radio transceiver (communicating with short-range technologies such as Bluetooth, Bluetooth Low Energy, Wi-Fi, WLAN, etc.). With the cellular radio transceiver, the measurement apparatus 110 and the processing apparatus 140 may be distributed so that they are located in the same town, in different towns, or even in different continents. With the non-cellular radio transceiver, the measurement apparatus 110 and the processing apparatus 140 need to be near each other, in the same room or in the same building, for example, except if there is a communication network in between (such as a wireless access point connected to the Internet), then the distribution degree may be the same as with the cellular radio transceiver. Note that the use of the cellular radio transceiver may necessitate the use of a subscriber identity module (SIM), and, consequently, the measurement apparatus 110 comprises a SIM card in a card reader, or a virtual (or software) SIM.

Note that the arrangement 100 may comprise other parts as well, which have not been described, but are naturally there: the measurement apparatus 110 comprises a power source (such as battery, which may be rechargeable) to feed electric energy to the sensors 114, 118, 120, 122, 124, 126, 128, 132, and also an interface, which collects the measurement data from the sensors 114, 118, 120, 122, 124, 126, 128, 132 to communicate the measurement data to the processing apparatus 140. The measurement data may be raw data from the sensors 114, 118, 120, 122, 124, 126, 128, 132, or it may be pre-processed before communicated to the processing apparatus 140.

In an example embodiment, the measurement apparatus 110 is designed to be totally non-invasive and painless to use.

In an example embodiment, the measurement apparatus 110 is divided into three main frames 112, 116, 130, possibly covered with a protective textile (with inner foam) or other material for comfort of use. Each of the frames 112, 116, 130 may be designed to fit the shape of the area it covers in order to ease its
5 positioning and improve the reproducibility of data acquisition with fixed sensors.

The first frame 116 is attachable to a knee 306 and comprises a medial audio sensor 124 positioned and configured to measure a medial sound caused by a movement of the leg 300 from a medial side of the knee 306, and a lateral audio sensor 126 positioned and configured to measure a lateral sound caused by the
10 movement of the leg 300 from a lateral side of the knee 306.

In an example embodiment, the medial audio sensor 124 comprises a non-contact microphone 230, and the lateral audio sensor 126 comprises a non-contact microphone 230.

In an example embodiment, the medial audio sensor 124 and the lateral
15 audio sensor 126 are both located below the patella 308.

The first frame 116 also comprises a medial thermal sensor 120 positioned and configured to measure a medial temperature from the medial side of the knee 306, and a lateral thermal sensor 122 positioned and configured to measure a lateral temperature from the lateral side of the knee 306.

In an example embodiment, the medial thermal sensor 120 comprises a
20 non-contact infrared sensor 234, and the lateral thermal sensor 122 comprises a non-contact infrared sensor 234.

As the sensors 118, 120, 122 124, 126 are non-contact, there is no need to use gel, making the measurement apparatus 110 easier to use.

The second frame 112 is attachable to a thigh 302 and comprises a thigh
25 inertial sensor 114 positioned and configured to measure thigh inertial data. Figure 4 illustrates an example embodiment of the structure of a main part 310 and a strap 312 of the second frame 112.

The third frame 130 is attachable to a lower leg 304 and comprises a
30 lower leg inertial sensor 132 positioned and configured to measure lower leg

inertial data. Figure 5 illustrates an example embodiment of the structure of a main part 320 and a strap 322 of the third frame 130.

In an example embodiment, the thigh inertial sensor 114 comprises a six degrees of freedom inertial measurement unit 232, and the lower leg inertial sensor 132 comprises a six degrees of freedom inertial measurement unit 232. Six degrees of freedom refers to the freedom of movement of a rigid body in three-dimensional space: change position as forward/backward (surge), up/down (heave), left/right (sway) translation in three perpendicular axes, combined with changes in orientation through rotation (pitch, yaw, and roll) about three perpendicular axes.

In an example embodiment, the inertial measurement sensor 114, 132 detects rate of acceleration using one or more accelerometers, and detects changes in rotational attributes (pitch, yaw and roll) using one or more gyroscopes.

In an example embodiment, multiple sizes of the second frame 112 and the third frame 130 are available based on the diameter of the thigh 302 and the lower leg 304.

In an example embodiment, one or two flexible straps 312, 322, 358, 360 are used to maintain the frames 112, 116, 130 in place.

In an example embodiment, the second frame 112 and the third frame 130 have the function to prevent the inertial sensors 114, 132 to be affected by skin movements since one inertial sensor 114, 132 is fixed on each frame 112, 130.

The first frame 116, the second frame 112 and the third frame 130 may be fully rigid (such as made of solid material) or at least rigid in the area where the acoustic and kinetic sensors are located so as not to be affected by skin movements and have a better normalization of the data measured with the sensors 124, 126, 114, 132.

In an example embodiment illustrated in more detail in Figure 6, the first frame 116 comprises a stable part 340 attachable to the lower leg, and a moving part 342, which is coupled with the stable part 340 to be positionable above a patella 308, and comprising the medial audio sensor 124, the lateral audio sensor 126, the medial thermal sensor 120, and the lateral thermal sensor 122.

In an example embodiment, the moving part 342 is coupled with the stable part 340 by a fastener 344 allowing the movement below the knee 306, by a first extensible part 600 at the medial side of the knee 306, and by a second extensible part 346 at the lateral side of the knee 306. In an example embodiment, 5 the fastener 344 is a hinge, but it may also be another kind of flexible structure allowing the movement including extension and flexion of the lower leg. In an example embodiment, the first extensible part 600 and the second extensible part 346 each comprise a spring, but also another kind of extensible material may be used such as rubber, or some other synthetic and/or natural material.

10 In an example embodiment, a tension of the first spring 600 is adjustable, and a tension of the second spring 346 is adjustable. In an example embodiment, the tension of the springs 346, 600 may be adjusted by shifting a fixing 356, 604 of the spring 346, 600 in a slot 606, 608 as illustrated in Figure 6.

In an example embodiment, a first position of a first fixing 602 of the 15 first spring 600 is adjustable, and a second position of a second fixing 348, 350, 352, 354 of the second spring 346 is adjustable. With this example embodiment, the fit of the moving part 342 above the patella 308 may be adjusted.

In an example embodiment, the stable part 340 may be attached on the upper tibia 304 by the mean of two straps 358, 360. In an example embodiment, 20 the moving part 342 is constantly pulled towards the patella 308 by the tensile springs 346, 600. By these means, the patient may walk and perform any movement that is requested by the data acquisition protocol without any discomfort.

In an example embodiment, the moving part 342 is always kept on the 25 top of the skin without affecting the comfort of the patient. The first frame 116 keeps the sensors 118, 120, 122, 124, 126 always at the same location on the knee 306 (and at the same distance to the skin), without restraining the patient in any way, meaning s/he can moves his/her knee 306 the same way he would without the measurement apparatus 110.

30 In an example embodiment, the first frame 116 is configured to provide a space between the medial audio sensor 124 and skin, the lateral audio sensor 126

and skin, the medial thermal sensor 120 and skin, and the lateral thermal sensor 122 and skin.

The structure of the first frame 116, and the placement of the audio sensors 124, 126 thereto avoids the generation of acoustic artefact.

5 In an example embodiment, three sensor frames 362, 368, 610 are fixed on the moving part 342, but may be removed to ease the change of sensors 118, 120, 122, 124, 126. These frames 362, 368, 610 have been designed to keep the sensors 118, 120, 122, 124, 126 at a constant distance from the skin of the user.

10 Figures 7, 8 and 9 illustrates example embodiments of sensor frames 362, 364, 366, 368, 612.

As shown in Figure 7, the sensor frame 362, 610 accommodates the thermal sensor 120/122 in a first slot 712, and the audio sensor 124/126 in a second slot 714. Ridges 706, 708 couple with grooves of the first frame 116 to keep the sensor frame 362, 610 aligned when being placed in a half sphere -shaped aperture in the first frame 116. Half sphere allows the rotation of the sensor frame 362, 610 to keep it aligned to the skin. This rotation is regulated by a curvature 710 (there is a counterpart structure in the first frame 116 to follow the curvature 710).

20 There is also a half sphere aperture 704 in the sensor frame 362, 610 to keep the sensor frame 362, 610 in position (there is a counterpart structure in the first frame 116 to couple with the half sphere aperture 704).

Slits 700, 702 on the sides of the sensor frame 362, 610 may be used to pass wires of the sensors 120, 122, 124, 126, which enables their easy replacement.

As shown in Figure 7, a groove 716 in the slots 712, 714 may be used to regulate the insertion depth of the sensors 120, 122, 124, 126.

25 Figure 8 illustrates example embodiments of the sensor frame 368. The reference thermal sensor 118 is inserted into an aperture 800. Wires of the sensor 118 may be routed through a slit 802. A groove 804 limits the insertion depth of the sensor 118 into the aperture 800.

30 Figure 9 illustrates example embodiments of the sensor frame 364, 366. The thigh inertial sensor 114 or the lower leg inertial sensor 132 is inserted into an aperture 900.

The processing apparatus 140 comprises one or more processors 144, and one or more memories 146 including computer program code 148.

The term 'processor' 144 refers to a device that is capable of processing data. Depending on the processing power needed, the processing apparatus 140
5 may comprise several processors 144 such as parallel processors or a multicore processor. When designing the implementation of the processor 144 a person skilled in the art will consider the requirements set for the size and power consumption of the processing apparatus 140, the necessary processing capacity, production costs, and production volumes, for example.

10 The term 'memory' 146 refers to a device that is capable of storing data run-time (= working memory) or permanently (= non-volatile memory). The working memory and the non-volatile memory may be implemented by a random-access memory (RAM), dynamic RAM (DRAM), static RAM (SRAM), a flash memory, a solid state disk (SSD), PROM (programmable read-only memory), a suitable
15 semiconductor, or any other means of implementing an electrical computer memory.

The processor 144 and the memory 146 may be implemented by an electronic circuitry. A non-exhaustive list of implementation techniques for the processor 144 and the memory 146 includes, but is not limited to: logic
20 components, standard integrated circuits, application-specific integrated circuits (ASIC), system-on-a-chip (SoC), application-specific standard products (ASSP), microprocessors, microcontrollers, digital signal processors, special-purpose computer chips, field-programmable gate arrays (FPGA), and other suitable electronics structures.

25 The computer program code 148 may be implemented by software and/or hardware. In an example embodiment, the software may be written by a suitable programming language (a high-level programming language, such as C, C++, or Java, or a low-level programming language, such as a machine language, or an assembler, for example), and the resulting executable code 148 may be stored
30 in the memory 146 and run by the processor 144. In an alternative example embodiment, the functionality of the hardware may be designed by a suitable

hardware description language (such as Verilog or VHDL), and transformed into a gate-level netlist (describing standard cells and the electrical connections between them), and after further phases the chip implementing the processor 144, memory 146 and the code 148 of the processing apparatus 100 may be fabricated with
5 photo masks describing the circuitry.

The one or more memories 146 and the computer program code 148 are configured to, with the one or more processors 144, cause the processing apparatus 140 at least to:

- analyze 202 the medial sound and the lateral sound to produce an
10 assessment 204 of a joint friction of the knee 306;
- analyze 206 the thigh inertial data and the lower leg inertial data to produce an assessment 208 of a malalignment of the knee 306;
- analyze 210 the medial temperature and the lateral temperature to produce an assessment 212 of an inflammation of the knee 306; and
- 15 - compile 214 an assessment 216 of a condition of the knee 306 based on the assessment 204 of the joint friction of the knee 306, the assessment 208 of the malalignment of the knee 306, and the assessment 212 of the inflammation of the knee 306.

The data acquisition is performed by acquiring signals from the knee
20 joint 306 using three modalities: acoustic (microphones on medial and lateral sides), thermal (temperature) in three locations (non-contact infrared sensors) and kinetic (6 degrees of freedom inertial measurement units). The arrangement 100 combines these three modalities together for the diagnostics of knee disorders.

The basis of choosing these modalities are as follows:

- 25 - Acoustic modality assesses the friction between the femoral and tibial cartilage, see the following, incorporated herein by reference: Mascaro B1, Prior J, Shark LK, Selfe J, Cole P, Goodacre J (2009). Exploratory study of a non-invasive method based on acoustic emission for assessing the dynamic integrity of knee joints. *Med Eng Phys.* 31(8): 1013-22.

- Thermal modality assesses the inflammation of the knee joint, see the following, incorporated herein by reference: Ammer K (2012). Temperature of the human knee – a review. *Thermology international* 22(4): 137-51.

- Kinetic modality provides information on knee malalignment as a
5 measure of varus/valgus angle within the joint, see the following, incorporated herein by reference: Chang A, Hochberg M, Song J, Dunlop D, et al. (2010). Frequency of varus and valgus thrust and factors associated with thrust presence in persons with or at higher risk of developing knee osteoarthritis. *Arthritis Rheum.* 62(5):1403-11.

10 During the signal acquisition, the user has to perform specific tasks (e.g. leg flexion and extension, sit-to stand, walking, etc.) to collect the relevant information for each sensor 114, 118, 120, 122, 124, 126, 132.

After the signal acquisition, the automatic multi-modal data analysis is performed and relevant features for each modality are extracted (e.g. differences
15 in temperatures, amount of acoustic emissions above a given threshold, varus/valgus angle, etc.).

In an example embodiment, in addition to the signal data, other variables such as age and body mass index are incorporated to the diagnostics algorithm. The final diagnostics may be performed using machine learning
20 techniques. Eventually, different algorithms may be used for classification. Additional diagnostic information may be provided by visualizing the measured data on a 2-dimensional plot using unsupervised machine learning methods. Such plot indicates the belonging of the analyzed subject to specific clusters corresponding to different conditions, such as early OA, mid-stage OA, end-stage
25 OA, etc.

As a final result, a diagnosis of a knee condition may be provided with an appropriate confidence interval. The diagnosis, naturally, may be subjected to an approval by authorized medical personnel.

In an example embodiment, patient clinical background information
30 (e.g. pain map + clinical evaluation), medical imaging information (X-ray etc.) may

be combined with the assessment 216 of the condition of the knee 306 in order to make a more specific diagnosis and prediction of knee condition.

As shown in Figure 1, a database 152 coupled with the processing apparatus 140 may be used to store data processed by the arrangement 100.

5 In an example embodiment, the processing apparatus 140 is further caused to analyze 206 the thigh inertial data and the lower leg inertial data to produce a varus/valgus angle 226 of the knee 306 as a part of the assessment 208 of the malalignment of the knee 306. As was explained earlier, the inertial sensors 114, 132 may provide raw data provided by both the accelerometer and gyroscope
10 of each inertial sensor 114, 132. Then, the processed data of the thigh inertial sensor 114 is related with the data from the lower leg inertial sensor 132 to assess the varus/valgus angle 226.

In an example embodiment, the processing apparatus 140 is further caused to analyze the thigh inertial data and the lower leg inertial data to produce
15 a flexion angle 224 of the knee 306 as a part of the assessment 208 of the malalignment of the knee 306.

In an example embodiment, the processing apparatus 140 is further caused to analyze the thigh inertial data and the lower leg inertial data to produce an assessment 228 of a ligament laxity of the knee 306 as a part of the assessment
20 208 of the malalignment of the knee 306.

In an example embodiment, the processing apparatus 140 is further caused to analyze the thigh inertial data and the lower leg inertial data to produce an assessment 220 of a deficiency in a cartilage of the knee 306 and/or an assessment 222 of a deficiency in a meniscus of the knee 306 as a part of the
25 assessment 208 of the malalignment of the knee 306.

In an example embodiment, the processing apparatus 140 is further caused to analyze the medial sound and the lateral sound to produce an assessment 220 of a deficiency in a cartilage of the knee 306 and/or an assessment 222 of a deficiency in a meniscus of the knee 306 as a part of the assessment 204 of the joint
30 friction of the knee 306.

In an example embodiment, the measurement apparatus 110 further comprises a reference thermal sensor 118 positioned and configured to measure a reference temperature from a patella 308, and the processing apparatus 140 is further caused to analyze 210 the medial temperature and the lateral temperature in view of the reference temperature in order to produce the assessment 212 of the inflammation of the knee 306. Instead, or additionally, the processing apparatus 140 may further be caused to analyze 210 the medial temperature and the lateral temperature in view of each other in order to produce the assessment 212 of the inflammation of the knee 306.

10 In an example embodiment, the reference thermal sensor 118 is positioned and configured on top of the centre of the patella 308 and it is used as reference for skin temperature.

In an example embodiment, the measurement apparatus 110 further comprises a vibration sensor 128 positioned and configured to measure vibration caused by the movement of the leg 300, and the processing apparatus 140 is further caused to analyze 236 the vibration to produce an assessment 238 of an instability of the knee 300, and compile 214 the assessment 216 of the condition of the knee 306 also based on the assessment 238 of the instability of the knee 306.

In an example embodiment, illustrated also in Figure 2, a method for knee diagnostics is provided. The operations are not strictly in chronological order, and some of the operations may be performed simultaneously or in an order differing from the given ones. Other functions may also be executed between the operations or within the operations and other data exchanged between the operations. Some of the operations or part of the operations may also be left out or replaced by a corresponding operation or a part of the operation. It should be noted that no special order of operations is required, except where necessary due to the logical requirements for the processing order. Note that also Figure 1 is referred to while explaining Figure 2.

The method starts in 200.

30 The method for knee diagnostics comprises:

analyzing 202 a medial sound and a lateral sound to produce an assessment 204 of a joint friction of the knee 306, wherein, both caused by a movement of the leg 300, the medial sound is measured with a medial audio sensor 124, and the lateral sound is measured with a lateral audio sensor 126;

5 analyzing 206 a thigh inertial data and a lower leg inertial data to produce an assessment 208 of a malalignment of the knee 306, wherein, both caused by a movement of the leg 300, the thigh inertial data is measured with a thigh inertial sensor 114, and the lower leg inertial data is measured with a lower leg inertial sensor 132;

10 analyzing 210 a medial temperature and a lateral temperature to produce an assessment 212 of an inflammation of the knee 306, wherein the medial temperature is measured with a medial thermal sensor 120, and the lateral temperature is measured with a lateral thermal sensor 122; and

compiling 214 an assessment 216 of a condition of the knee 306 based
15 on the assessment 204 of the joint friction of the knee 306, the assessment 208 of the malalignment of the knee 306, and the assessment 212 of the inflammation of the knee 306.

The method ends in 218.

The example embodiments of the arrangement 100, measurement
20 apparatus 110, and the processing apparatus 140 may be utilized to enhance the method with various further example embodiments. For example, various structural and/or operational details may supplement the method.

In an example embodiment, the sensors 114, 118, 120, 122, 124, 126,
132 are constituent parts of a measurement apparatus 110 attachable to the leg
25 300.

It will be obvious to a person skilled in the art that, as technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the example embodiments described above but may vary within the scope of the claims.

Claims

1. An arrangement (100) for knee diagnostics comprising a measurement apparatus (110) attachable to a leg (300), and a processing apparatus (140) communicatively couplable (160) with the measurement apparatus (110), the measurement apparatus (110) comprising:

5 a first frame (116) attachable to a knee (306), the first frame (116) comprising a medial audio sensor (124) positioned and configured to measure a medial sound caused by a movement of the leg (300) from a medial side of the knee (306), and a lateral audio sensor (126) positioned and configured to measure a lateral sound caused by the movement of the leg (300) from a lateral side of the knee (306), the first frame (116) also comprising a medial thermal sensor (120) positioned and configured to measure a medial temperature from the medial side of the knee (306), and a lateral thermal sensor (122) positioned and configured to measure a lateral temperature from the lateral side of the knee (306), wherein the first frame (116) is configured to provide a space between the medial audio sensor (124) and skin, and a space between the lateral audio sensor (126), whereby a generation of an acoustic artefact is avoided, and wherein the first frame (116) comprises a stable part (340) attachable to the lower leg (304), and a moving part (342), which is coupled with the stable part (340) to be positionable above a patella (308), and comprising the medial audio sensor (124), the lateral audio sensor (126), the medial thermal sensor (120), and the lateral thermal sensor (122), whereby knee is movable as without the measurement apparatus (110);

15 a second frame (112) attachable to a thigh (302), the second frame (112) comprising a thigh inertial sensor (114) positioned and configured to measure thigh inertial data; and

20 a third frame (130) attachable to a lower leg (304), the third frame (130) comprising a lower leg inertial sensor (132) positioned and configured to measure lower leg inertial data; and the processing apparatus (140) comprising:

one or more processors (144); and

30 one or more memories (146) including computer program code (148);

the one or more memories (146) and the computer program code (148) configured to, with the one or more processors (144), cause the processing apparatus (140) at least to:

analyze (202) the medial sound and the lateral sound to
5 produce an assessment (204) of a joint friction of the knee (306);

analyze (206) the thigh inertial data and the lower leg inertial data to produce an assessment (208) of a malalignment of the knee (306);

analyze (210) the medial temperature and the lateral temperature to produce an assessment (212) of an inflammation of the knee (306);

10 and

compile (214) an assessment (216) of a condition of the knee (306) based on the assessment (204) of the joint friction of the knee (306), the assessment (208) of the malalignment of the knee (306), and the assessment (212) of the inflammation of the knee (306).

15 2. The arrangement of claim 1, wherein the moving part (342) is coupled with the stable part (340) by a fastener (344) allowing the movement below the knee (306), by a first extensible part (600) at the medial side of the knee (306), and by a second extensible part (346) at the lateral side of the knee (306).

20 3. The arrangement of claim 2, wherein a tension of the first extensible part (600) is adjustable, and a tension of the second extensible part (346) is adjustable.

25 4. The arrangement of claim 2 or 3, wherein a first position of a first fixing (602) of the first extensible part (600) is adjustable, and a second position of a second fixing (348, 350, 352, 354) of the second extensible part (346) is adjustable.

5. The arrangement of any preceding claim, wherein the first frame (116) is configured to provide a space between the medial audio sensor (124) and skin, the lateral audio sensor (126) and skin, the medial thermal sensor (120) and skin, and the lateral thermal sensor (122) and skin.

6. The arrangement of any preceding claim, wherein the medial audio sensor (124) comprises a non-contact microphone, and the lateral audio sensor (126) comprises a non-contact microphone.

7. The arrangement of any preceding claim, wherein the medial thermal sensor (120) comprises a non-contact infrared sensor, and the lateral thermal sensor (122) comprises a non-contact infrared sensor.

8. The arrangement of any preceding claim, wherein the measurement apparatus (110) further comprises a reference thermal sensor (118) positioned and configured to measure a reference temperature from a patella (308), and the processing apparatus (140) is further caused to analyze (210) the medial temperature and the lateral temperature in view of the reference temperature in order to produce the assessment (212) of the inflammation of the knee (306).

9. The arrangement of any preceding claim, wherein the thigh inertial sensor (114) comprises a six degrees of freedom inertial measurement unit, and the lower leg inertial sensor (132) comprises a six degrees of freedom inertial measurement unit.

10. The arrangement of any preceding claim, wherein the processing apparatus (140) is further caused to analyze (206) the thigh inertial data and the lower leg inertial data to produce a varus/valgus angle (226) of the knee (306) as a part of the assessment (208) of the malalignment of the knee (306).

11. The arrangement of any preceding claim, wherein the processing apparatus (140) is further caused to analyze the thigh inertial data and the lower leg inertial data to produce a flexion angle (224) of the knee (306) as a part of the assessment (208) of the malalignment of the knee (306).

12. The arrangement of any preceding claim, wherein the processing apparatus (140) is further caused to analyze the thigh inertial data and the lower leg inertial data to produce an assessment (228) of a ligament laxity of the knee (306) as a part of the assessment (208) of the malalignment of the knee (306).

13. The arrangement of any preceding claim, wherein the processing apparatus (140) is further caused to analyze the thigh inertial data and the lower leg inertial data to produce an assessment (220) of a deficiency in a cartilage of the

knee (306) and/or an assessment (222) of a deficiency in a meniscus of the knee (306) as a part of the assessment (208) of the malalignment of the knee (306).

14. The arrangement of any preceding claim, wherein the processing apparatus (140) is further caused to analyze the medial sound and the lateral
5 sound to produce an assessment (220) of a deficiency in a cartilage of the knee (306) and/or an assessment (222) of a deficiency in a meniscus of the knee (306) as a part of the assessment (204) of the joint friction of the knee (306).

15. The arrangement of any preceding claim, wherein the measurement apparatus (110) further comprises a transmitter (134) to communicatively couple
10 (160) the measurement apparatus (110) with the processing apparatus (140).

16. The arrangement of any preceding claim, wherein the measurement apparatus (110) further comprises a vibration sensor (128) positioned and configured to measure vibration caused by the movement of the leg (300), and the processing apparatus (140) is further caused to analyze (230) the vibration to
15 produce an assessment (232) of an instability of the knee (300), and compile (214) the assessment (216) of the condition of the knee (306) also based on the assessment (232) of the instability of the knee (306).

17. The measurement apparatus (110) of any preceding claim 1 to 16, wherein the measurement apparatus (110) comprises:

20 a first frame (116) attachable to a knee (306), the first frame (116) comprising a medial audio sensor (124) positioned and configured to measure a medial sound caused by a movement of the leg (300) from a medial side of the knee (306), and a lateral audio sensor (126) positioned and configured to measure a lateral sound caused by the movement of the leg (300) from a lateral side of the
25 knee (306), the first frame (116) also comprising a medial thermal sensor (120) positioned and configured to measure a medial temperature from the medial side of the knee (306), and a lateral thermal sensor (122) positioned and configured to measure a lateral temperature from the lateral side of the knee (306), wherein the first frame (116) is configured to provide a space between the medial audio sensor
30 (124) and skin, and a space between the lateral audio sensor (126), whereby a generation of an acoustic artefact is avoided, and wherein the first frame (116)

comprises a stable part (340) attachable to the lower leg (304), and a moving part (342), which is coupled with the stable part (340) to be positionable above a patella (308), and comprising the medial audio sensor (124), the lateral audio sensor (126), the medial thermal sensor (120), and the lateral thermal sensor (122),
5 whereby knee is movable as without the measurement apparatus (110);

a second frame (112) attachable to a thigh (302), the second frame (112) comprising a thigh inertial sensor (114) positioned and configured to measure thigh inertial data; and

a third frame (130) attachable to a lower leg (304), the third frame
10 (130) comprising a lower leg inertial sensor (132) positioned and configured to measure lower leg inertial data.

18. The processing apparatus (140) of any preceding claim 1 to 16, wherein the processing apparatus (140) comprises:

one or more processors (144); and

15 one or more memories (146) including computer program code (148);
the one or more memories (146) and the computer program code (148) configured to, with the one or more processors (144), cause the processing apparatus (140) at least to:

analyze (202) the medial sound and the lateral sound to
20 produce an assessment (204) of a joint friction of the knee (306);

analyze (206) the thigh inertial data and the lower leg inertial data to produce an assessment (208) of a malalignment of the knee (306);

analyze (210) the medial temperature and the lateral temperature to produce an assessment (212) of an inflammation of the knee (306);

25 and

compile (214) an assessment (216) of a condition of the knee (306) based on the assessment (204) of the joint friction of the knee (306), the assessment (208) of the malalignment of the knee (306), and the assessment (212) of the inflammation of the knee (306).

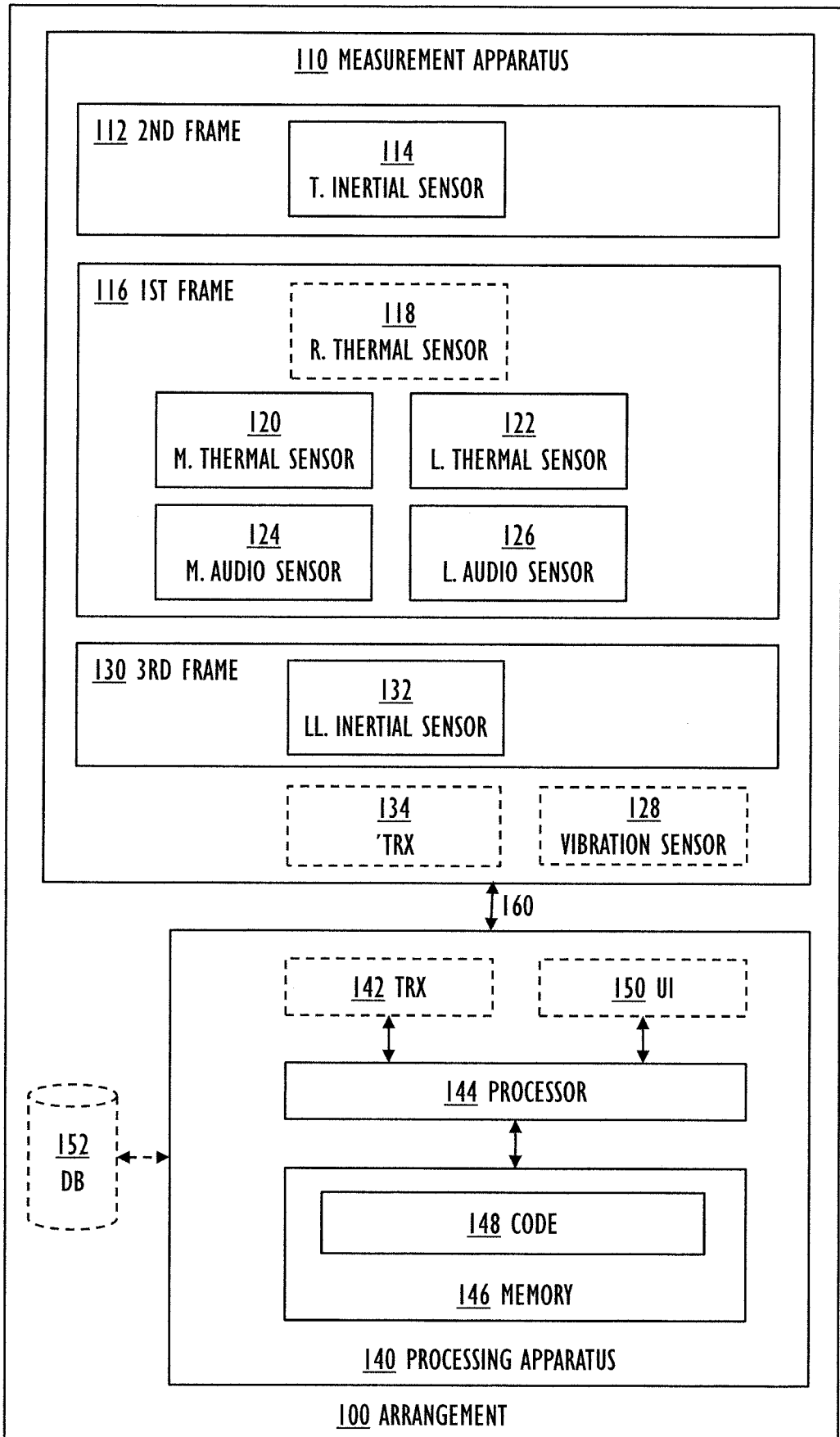


FIG. 1

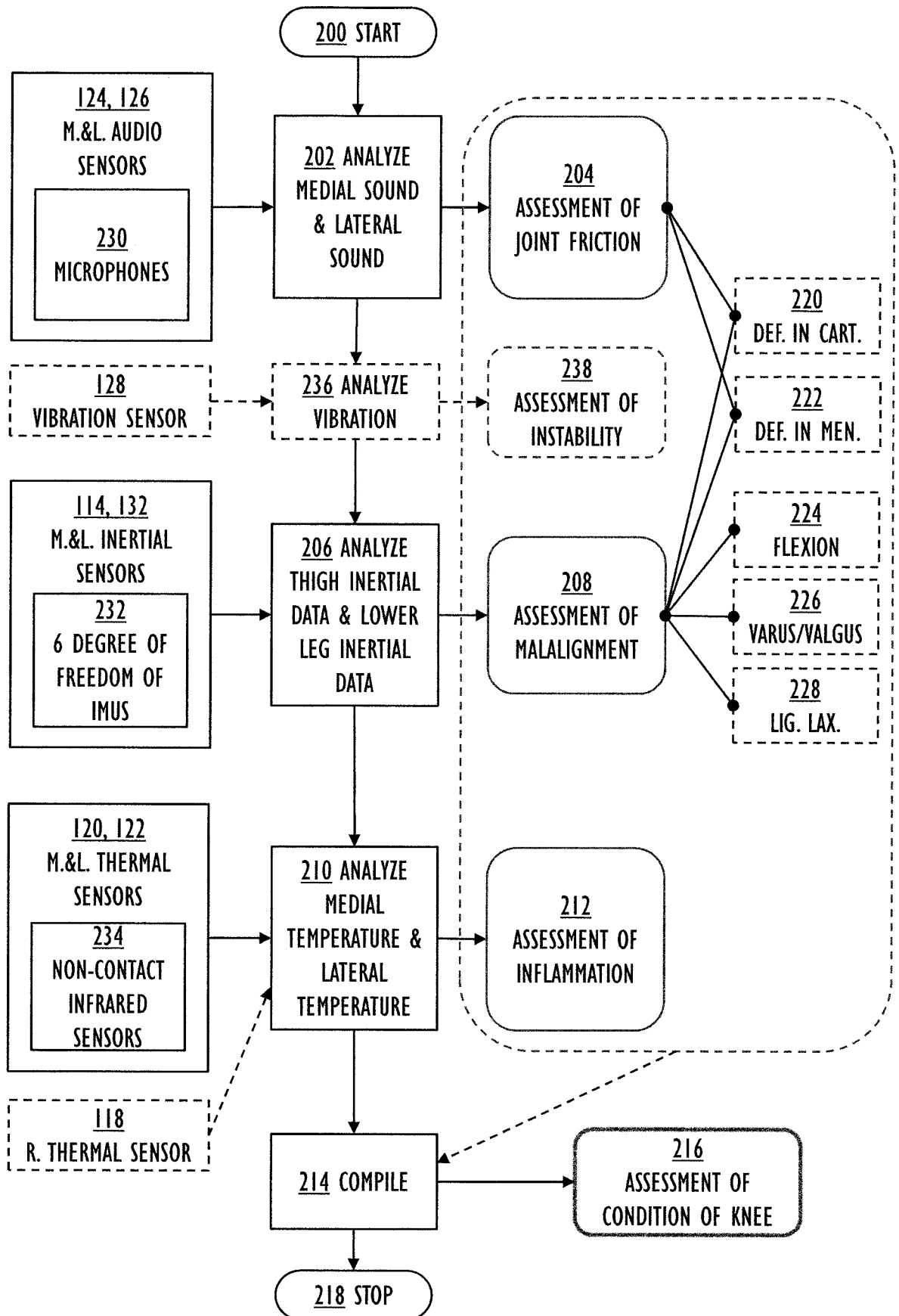


FIG. 2

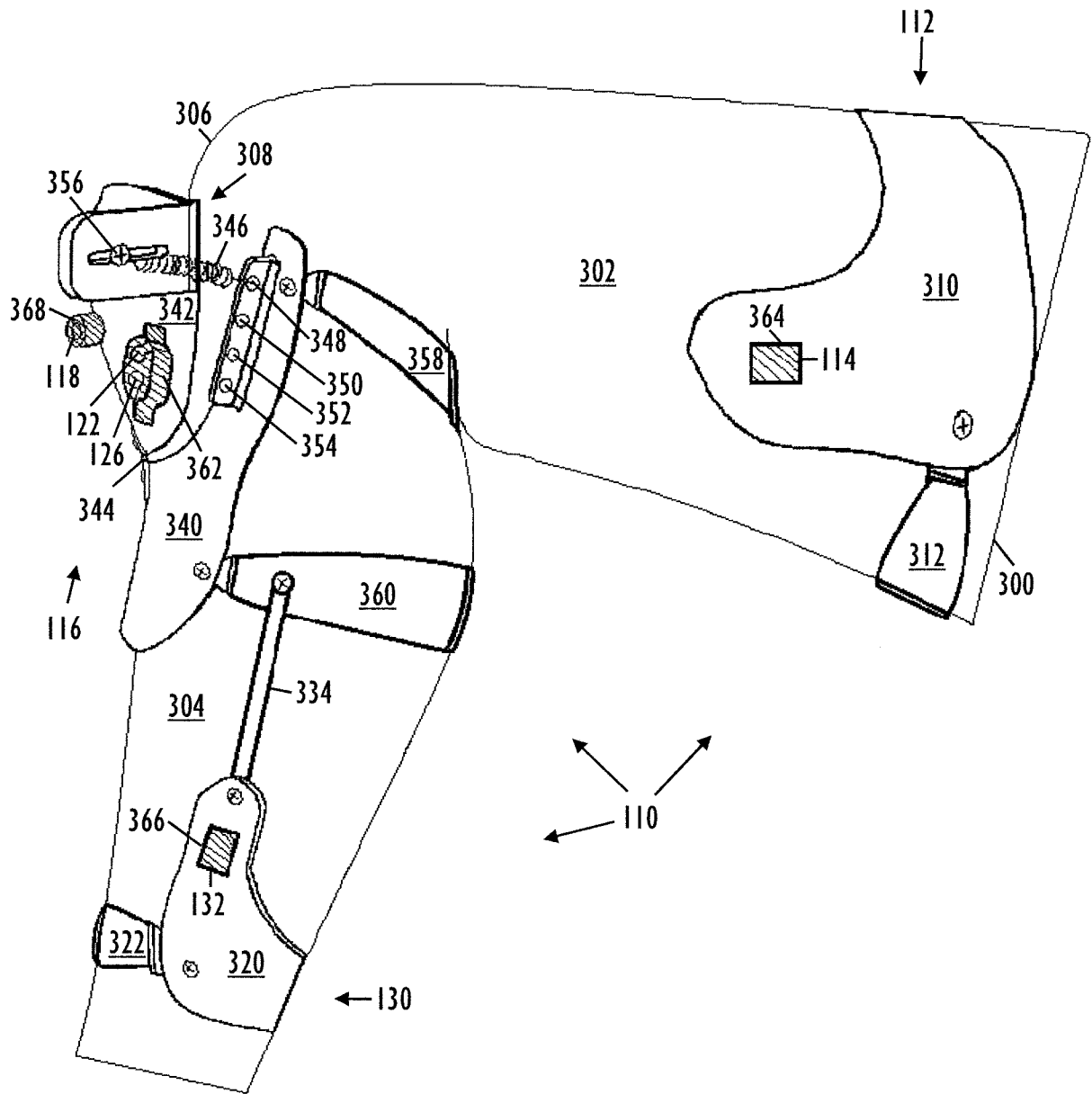


FIG. 3

4/7

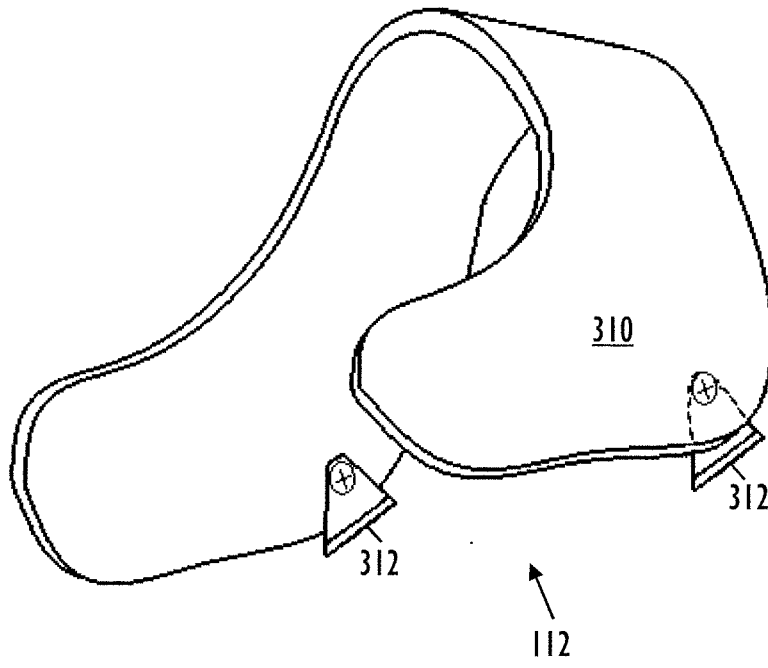


FIG. 4

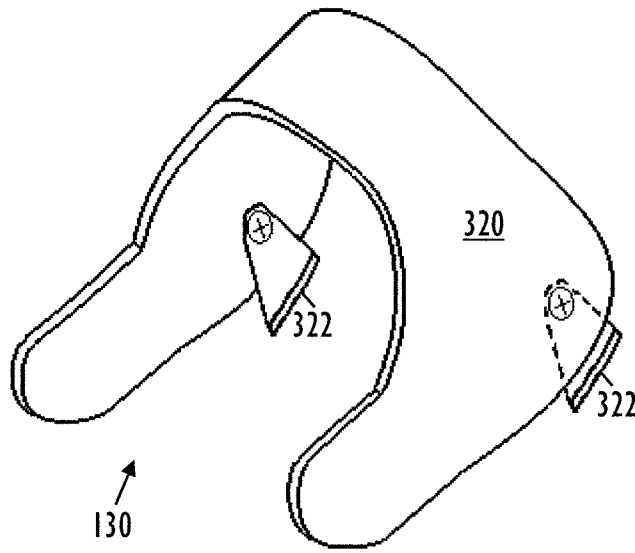


FIG. 5

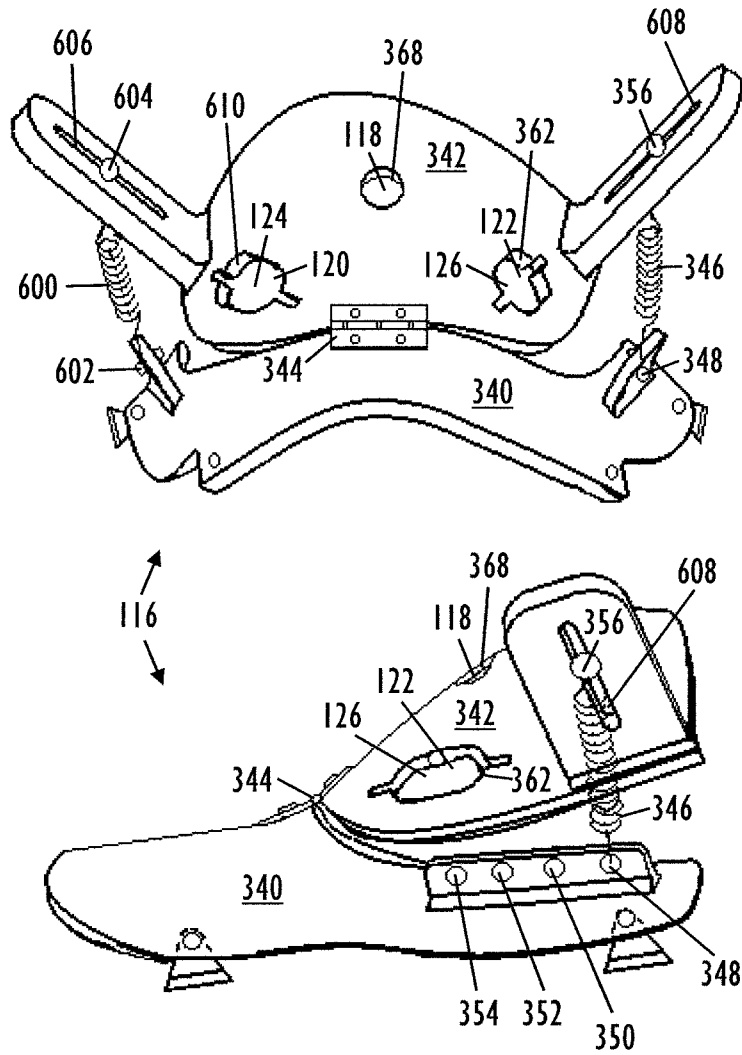


FIG. 6

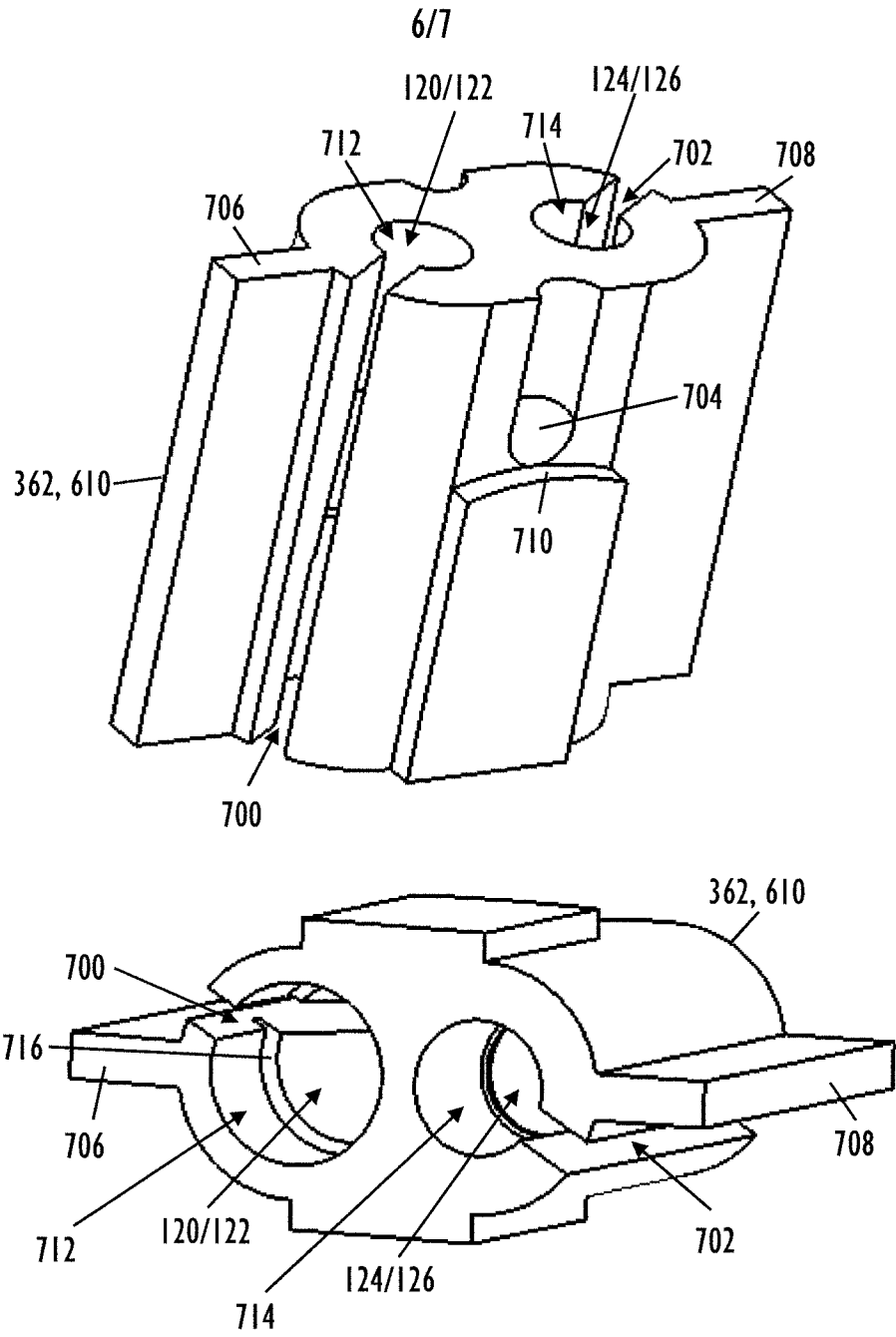


FIG. 7

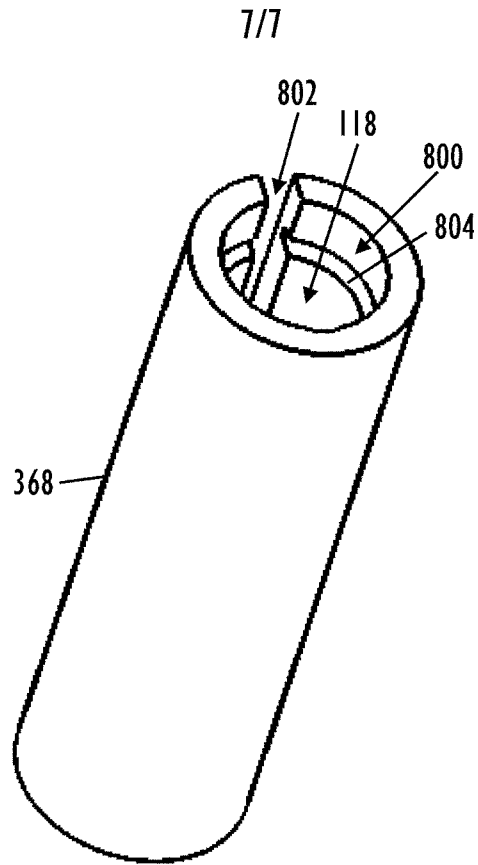


FIG. 8

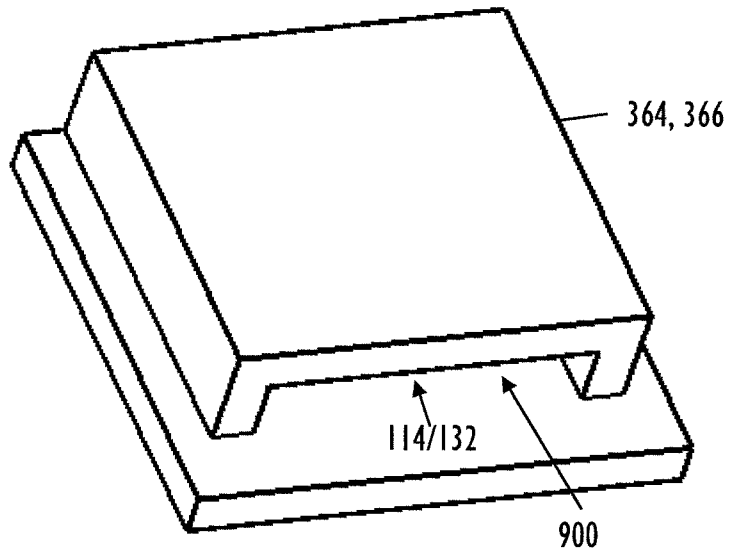


FIG. 9

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 2161895PC	FOR FURTHER ACTION see Form PCT/ISA/220 as well as, where applicable, item 5 below.	
International application No. PCT/FI2017/050760	International filing date (<i>day/month/year</i>) 3 November 2017 (03-11-2017)	(Earliest) Priority Date (<i>day/month/year</i>) 7 November 2016 (07-11-2016)
Applicant OULUN YLIOPISTO		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of:

- the international application in the language in which it was filed
 a translation of the international application into _____, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

b. This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6**bis**(a)).

c. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. **Certain claims were found unsearchable** (See Box No. II)

3. **Unity of invention is lacking** (see Box No III)

4. With regard to the **title**,

- the text is approved as submitted by the applicant
 the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

- the text is approved as submitted by the applicant
 the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings**,

- a. the figure of the **drawings** to be published with the abstract is Figure No. 3
 as suggested by the applicant
 as selected by this Authority, because the applicant failed to suggest a figure
 as selected by this Authority, because this figure better characterizes the invention
- b. none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2017/050760

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/01 A61B5/11 A61B7/00
ADD. A61B5/00

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)
A61B

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 2016/302721 A1 (WIEDENHOEFER CURT [US] ET AL) 20 October 2016 (2016-10-20) paragraphs [0037] - [0041]; figure 1 paragraph [0044]; figure 2 paragraphs [0051], [0052], [0054] paragraphs [0059] - [0061] paragraphs [0065] - [0068]; figure 3 paragraphs [0073] - [0074]; figures 7A-7B paragraphs [0080], [0082] - [0083] paragraph [0087]	1-18
X	US 2014/128689 A1 (STEWART KIRK W [US] ET AL) 8 May 2014 (2014-05-08) paragraphs [0041] - [0048]; figures 1, 12 paragraphs [0054], [0064] paragraphs [0065], [0067], [0072] paragraphs [0073] - [0074] paragraphs [0102] - [0107]	1-18
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Further documents are listed in the continuation of Box C.

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 12 January 2018	Date of mailing of the international search report 19/01/2018
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Sarcia, Regis

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2017/050760

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/161731 A1 (WOODS SHERROD A [US] ET AL) 3 July 2008 (2008-07-03) paragraphs [0026] - [0029], [0031], [0033] - [0034]; figures 1-2 paragraphs [0036] - [0040]; figures 5-6 paragraph [0052] -----	1,17
A	HAIDAR S G ET AL: "Knee skin temperature following uncomplicated total knee replacement", THE KNEE, ELSEVIER, AMSTERDAM, NL, vol. 13, no. 6, 1 December 2006 (2006-12-01), pages 422-426, XP027992087, ISSN: 0968-0160 [retrieved on 2006-12-01] sections 1-2; figure 1; table 1 -----	1-18
A	US 2013/253379 A1 (MAHFOUZ MOHAMED R [US] ET AL) 26 September 2013 (2013-09-26) paragraphs [0042], [0050], [0060]; figures 3-4 paragraphs [0048] - [0049]; figure 7 -----	1-18
A	US 2004/054302 A1 (CZERNICKI JACEK [DE]) 18 March 2004 (2004-03-18) paragraph [0120]; figure 5 paragraphs [0027] - [0029], [0128], [0131], [0134], [0146] -----	1,13,14, 17
A	US 2013/041289 A1 (SENA MARK [US] ET AL) 14 February 2013 (2013-02-14) paragraphs [0036], [0044]; figure 4b -----	2-4,11
A	US 2015/032034 A1 (PETRIGLIANO FRANK A [US] ET AL) 29 January 2015 (2015-01-29) paragraphs [0028] - [0031]; figures 1-3 paragraphs [0039], [0047], [0058]; figures 6-7 paragraph [0062] -----	9,12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/FI2017/050760

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2016302721 A1	20-10-2016	AU 2016235325 A1	02-11-2017
		AU 2016267980 A1	02-11-2017
		EP 3273846 A1	31-01-2018
		EP 3273858 A1	31-01-2018
		US 2016302721 A1	20-10-2016
		US 2016310066 A1	27-10-2016
		WO 2016154230 A1	29-09-2016
		WO 2016190948 A1	01-12-2016

US 2014128689 A1	08-05-2014	US 2014128689 A1	08-05-2014
		WO 2012139007 A1	11-10-2012

US 2008161731 A1	03-07-2008	EP 1938749 A2	02-07-2008
		US 2008161731 A1	03-07-2008

US 2013253379 A1	26-09-2013	CA 2751422 A1	05-08-2010
		CA 2977574 A1	05-08-2010
		EP 2391971 A1	07-12-2011
		JP 5723788 B2	27-05-2015
		JP 6005715 B2	12-10-2016
		JP 2012516719 A	26-07-2012
		JP 2015109972 A	18-06-2015
		JP 2016202974 A	08-12-2016
		US 2010198067 A1	05-08-2010
		US 2012029345 A1	02-02-2012
		US 2013217998 A1	22-08-2013
		US 2013253379 A1	26-09-2013
		US 2017296115 A1	19-10-2017
		WO 2010088696 A1	05-08-2010

US 2004054302 A1	18-03-2004	AU 5629001 A	30-10-2001
		DE 10018654 A1	13-12-2001
		DE 20121343 U1	20-02-2003
		EP 1276418 A2	22-01-2003
		US 2004054302 A1	18-03-2004
		WO 0178645 A2	25-10-2001

US 2013041289 A1	14-02-2013	NONE	

US 2015032034 A1	29-01-2015	EP 2814392 A1	24-12-2014
		US 2015032034 A1	29-01-2015
		WO 2013123263 A1	22-08-2013

专利名称(译)	膝关节诊断的安排		
公开(公告)号	EP3534782A1	公开(公告)日	2019-09-11
申请号	EP2017809332	申请日	2017-11-03
申请(专利权)人(译)	欧伦YLIOPISTO		
当前申请(专利权)人(译)	欧伦YLIOPISTO		
[标]发明人	THEVENOT JEROME SAARAKKALA SIMO TIULPIN ALEKSEI		
发明人	THEVENOT, JÉROME SAARAKKALA, SIMO TIULPIN, ALEKSEI		
IPC分类号	A61B5/01 A61B5/11 A61B7/00 A61B5/00		
CPC分类号	A61B5/01 A61B5/1121 A61B5/4504 A61B5/4514 A61B5/4533 A61B5/4585 A61B5/6812 A61B5/6823 A61B5/6828 A61B5/7267 A61B7/006 A61B5/112 A61B5/4528 A61B5/4538 A61B5/7282		
代理机构(译)	KOLSTER OY AB		
优先权	2016005832 2016-11-07 FI		
外部链接	Espacenet		

摘要(译)

一种用于膝盖诊断的装置 (100) , 包括可附接到腿的测量装置 (110) 和处理装置 (140) 。测量设备 (110) 包括具有各种传感器的三个框架 (112,116,130) : 音频传感器 (124,126) , 热传感器 (120,122) 和惯性传感器 (114,132) 。使处理设备 (140) : 分析 (202) 内侧声音和侧向声音以产生膝盖关节摩擦的评估 (204) 分析 (206) 所述大腿惯性数据和所述小腿惯性数据以产生所述膝盖的排列不齐的评估 (208) ;分析 (210) 内侧温度和外侧温度以产生膝盖炎症的评估 (212) ;以及基于所述评估 (204,208,212) 编译 (214) 对膝盖 (306) 的状况的评估 (216) 。