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(54) **KNEE JOINT PATHOLOGY EVALUATION AND DIAGNOSTIC AID**

BEURTEILUNG UND UNTERSTÜTZUNG DER DIAGNOSE VON KNIEGELENKERKRANKUNGEN

AIDE À L'ÉVALUATION ET AU DIAGNOSTIC D'UNE PATHOLOGIE DE L'ARTICULATION DU GENOU

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- **JEFFERSON R J ET AL: "Biomechanical assessment of unicompartmental knee arthroplasty, total condylar arthroplasty and tibial osteotom", CLINICAL BIOMECHANICS, BUTTERWORTH SCIENTIFIC LTD, GUILDFORD, GB, vol. 4, no. 4, 1 November 1989 (1989-11-01), pages 232-242, XP026183183, ISSN: 0268-0033, DOI: 10.1016/0268-0033(89)90008-9 [retrieved on 1989-11-01]**

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from US Application no. 12/772,701 dated May 3, 2010.

TECHNICAL FIELD

[0002] This description relates to the field of knee joint movement analysis methods and apparatuses. More particularly, this description relates to apparatuses and methods for evaluating knee joint pathologies and injuries based on kinematic data.

BACKGROUND

[0003] Studies have shown that musculoskeletal disorders represent the second most important health-related costs in almost all industrialized countries, close behind cardiovascular diseases, and ahead of cancer and neurological diseases. By musculoskeletal disorders, it is intended to refer to disease of cartilage, bone, muscle, ligaments and tendons. With the current progressive increase in life expectancy, musculoskeletal problems have become more prevalent in the population, resulting in an increase in the number of available pharmacological treatments and therapeutic devices. With the emergence of new treatment modalities came the development new instruments for the detection, the evaluation and the monitoring of knee joint injuries and pathologies.

[0004] The knee is an extremely complex joint necessitating a perfectly coupled three-dimensional range of movement for proper function. Knee joint functions are thus better evaluated via analysis of their three-dimensional components, using a quantified functional approach reflective of movements of bones of the knee joint in one of the three-dimensional planes.

[0005] Current methods involve the use of radiological examinations (such as X-rays, MRI, and CT-Scans). Such exams however typically remain limited in terms of their capacity to evaluate various functional aspects of the knee joint, and typically cannot be performed while the knee joint is moving (i.e. they are static in nature).

[0006] Other existing methods used to evaluate knee joints function typically involve static imaging combined with manual testing (ligament laxity). Since these tests rely on manual testing and patient compliance, they are tainted by a certain amount of subjectivity.

[0007] Some existing methods permit the quantification of anteroposterior movement of the tibia with respect to the femur (such as the KT-1000). These methods however do not permit precise and reliable evaluation of the knee joint as they are typically limited to performing a static evaluation of a translation movement. Such methods are typically not suitable for performing an evolution as a movement is being performed by the knee joint.

[0008] There is therefore a need for an improved apparatus and method for evaluating knee joint function and disorders or pathologies, which addresses shortcomings associated with the prior art, or at least provides a useful alternative.

[0009] The disclosure of the following documents is relevant for understanding the background of the present invention: US2009/198155 (A1), EP1880694 (A1); together with Jefferson J et al: "Biomechanical assessment of unicompartmental knee arthroplasty, total condylar arthroplasty and tibial osteotom",CLINICAL BIOMECHANICS, BUTTERWORTH SCIENTIFIC LTD, GUILDFORD, GB, vol. 4, no. 4, 1 November 1989 (1989-11-01), pages 232-242; along with Li et al: "An integrated procedure to assess knee-joint kinematics and kinetics during gait using an optoelectric system and standardized X-rays",JOURNAL OF BIOMEDICAL ENGINEERING, BUTTERWORTH, GUILDFORD, GB, vol. 15, no. 5, 1 September 1993 (1993-09-01), pages 392-400.

SUMMARY

[0010] According to an embodiment, there is provided a method for identifying and characterizing a problem of a knee joint. In accordance with an embodiment, the method comprises receiving biomechanical data from sensors and generating a biomechanical profile based on the biomechanical data, the biomechanical data being representative of a movement of the knee joint. The method also involves, in a processing device, classifying the biomechanical profile of the knee joint in one of multiple classes of knee joint problems by applying a computer implemented pattern recognition technique to a normative biomechanical profile associated to the one of the multiple classes, each one of the multiple classes corresponding to at least one knee joint problem; based on the classifying, identifying the problem as comprising the at least one knee joint problem of the one of the multiple classes; and archiving the problem identified in a storing device to make the problem accessible during consultation.

[0011] According to an embodiment, the biomechanical profile is a continuous biomechanical profile based on the biomechanical data, the continuous biomechanical profile comprising a continuous curve representative of the biomechanical data for the knee joint as a function of a percentage of the complete cycles of the movement of the knee joint, where each input represents a percentage of completion of the complete cycle of the movement of the knee joint.

[0012] According to an embodiment, the outputs represent one of: - a degree of extension-flexion of the knee joint of the patient corresponding to the percentage of completion of the complete cycle of the knee joint; - a degree of abduction-adduction of the knee joint of the patient corresponding to the percentage of completion of the complete cycle of the knee joint; and - a degree of internal-external rotation of the knee joint of the patient corresponding to the percentage of completion of the complete cycle of the knee joint.

[0013] According to an embodiment, the outputs represent one of: - a vertical ground reaction force exerted on the patient corresponding to the percentage of completion of the complete cycle of the knee joint; - a medial/lateral ground reaction force exerted on the patient corresponding to the percentage of completion of the complete cycle of the knee joint; and - a posterior/anterior ground reaction force exerted on the patient corresponding to the percentage of completion of the complete cycle of the knee joint;

[0014] According to an embodiment, the classifying comprises classifying the continuous biomechanical profile of the knee joint.

[0015] According to another embodiment, the classifying comprises comparing the biomechanical profile to the set of normative biomechanical profiles.

[0016] According to another embodiment, the receiving comprises receiving the biomechanical data as the movement is being performed by the knee joint.

[0017] According to another embodiment, the generating of the biomechanical profile comprises quantifying a function of the knee joint versus a time elapsed during the movement.

[0018] According to another embodiment, the pattern recognition technique comprises at least one of: a neural network, a nearest neighbour classification technique, a projection technique, and a decision tree technique.

[0019] According to another embodiment, the method further comprises comparing the biomechanical profile to a past biomechanical profile generated for the same knee joint at an earlier time; and quantifying at least one of: a progression of the problem and an effect of a treatment performed on the knee joint, based on the classifying.

[0020] According to another embodiment, the receiving the biomechanical data comprises receiving at least one of kinematic data; kinetic data; and data of ground reaction forces.

[0021] According to another embodiment, each one of the multiple classes is indicative of at least one of: a knee joint injury; a knee joint pathology; a class of knee joint pathologies; and a class of knee joint injuries.

[0022] According to another embodiment, the identifying comprises identifying the problem as comprising at least two knee joint problems, the one of the multiple classes being associated to the at least two knee joint problems.

[0023] According to another embodiment, the method further comprises sorting the at least two knee joint problems based on a respective degree of severity for each one of the at least two knee joint problems.

[0024] According to another embodiment, the classifying comprises determining an amount of similarity between the biomechanical profile and at least one of the set of normative biomechanical profiles.

[0025] According to another embodiment, the method further comprises at least one of: generating a report to include an identification of the problem; and displaying the report with the identification of the problem, the identification comprising at least one of: a name for the at least one knee joint problem; the amount of similarity; and the biomechanical profile with an indication of a problematic area associated with the at least one knee joint problem.

[0026] According to another embodiment, the method further comprises generating a recommendation based on a pre-established treatment associated to the at least one knee joint problem.

[0027] According to another embodiment, there is provided an apparatus for identifying and characterizing a problem of a knee joint. The apparatus comprises: sensors for attachment to a knee joint, the sensors for gathering biomechanical data representative of a movement of a knee joint; a processor in communication with the sensors; and a memory device accessible by the processor. The memory device stores instructions for retrieval by the processor to implement the processor to: receive the biomechanical data from the sensors; generate a biomechanical profile based on the biomechanical data; classify the biomechanical profile of the knee joint in one of multiple classes of knee joint problems by applying a computer implemented pattern recognition technique to a set of normative biomechanical profiles associated to the multiple classes, each one of the multiple classes corresponding to at least one knee joint problem; based on the classifying, identify the problem as comprising the at least one knee joint problem of the one of the multiple classes; and archive the problem identified to allow retrieval of the problem during a medical consultation.

[0028] According to another embodiment, the apparatus further comprises a display device for displaying the problem identified.

[0029] According to another embodiment, the apparatus further comprises a graphical user interface (GUI) for allowing a user interaction with the processor.

[0030] According to another embodiment, the sensors comprise a three-dimensional knee movement analyser having at least one of: an optical tracking device; an electromagnetic tracking device and an accelerometer.

[0031] According to another embodiment, the instructions for classifying comprise instructions implementing the processor to compare the biomechanical profile to the set of normative biomechanical profiles.

[0032] According to another embodiment, the sensors comprise sensors for gathering at least one of kinematic data; kinetic data; and data on ground reaction forces as biomechanical data.

[0033] According to another embodiment, the sensors comprise kinematic sensors for gathering kinematic data as a sole input.

[0034] According to another embodiment, there is provided a computer readable media storing instructions for implementing a processor to identify a problem of a knee joint. The instructions comprise coding for implementing the processor to: receive biomechanical data from sensors, the biomechanical data being representative of a movement of the knee joint; generate a biomechanical profile based on the biomechanical data; classify the biomechanical profile of the knee joint in one of multiple classes of knee joint problems by applying a pattern recognition technique to a set of normative biomechanical profiles associated to the multiple classes, each one of the multiple classes corresponding to at least one knee joint problem; based on the classifying, identify the problem as comprising the at least one knee joint problem of the one of the multiple classes; and archive the problem identified in a storing device to make the problem accessible during consultation.

[0035] The scope of protection is defined in the appended claims.

[0036] In the present description, the term "kinematic data" refers to data reflective of a combination of position, speed and acceleration of a body member such as a bone involved in a knee joint for example, irrespective of any physical force applied thereto. Kinematic data is obtainable using motion sensors such as those employed in creating animation-type movies.

[0037] By comparison, the term "kinetic" refers to the forces applied to the knee joint, while ground reaction forces refer to forces applied to a limb, from a given surface such as the ground during a gait cycle for example. Both ground reaction forces and kinetic data are obtainable using force sensors placed at various areas such as on the limb and the ground.

[0038] In addition, the term "normative" is used in the present description as meaning representative. A "normative biomechanical profile" is thus intended to refer to a biomechanical profile which is known to be representative or which is associated to a specifically known knee joint problem or class of knee joint problem(s).Such a normative profile can be compiled from profiles of a number of subjects having a diagnosed problem for example, and the data optionally normalized or averaged for all these subjects.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] Further features and advantages of the present disclosure will become apparent from the following detailed description, taken in combination with the appended drawings, in which:

Fig. 1a is an illustration of the femur and the tibia of a knee joint, which shows three planes of motion of the knee joint, in accordance with common general knowledge associated with prior art;

Fig. 1b is an illustration of a patient's knee joint with a sensor, and showing the three planes of motion of Fig. 1a, in accordance with an embodiment;

Fig. 2 is a schematic illustration of an apparatus for identifying and characterizing a knee joint problem, in accordance with another embodiment;

Fig. 3 is a flow chart of a method for identifying and characterizing a knee joint problem, in accordance with an embodiment;

Fig. 4a is a graphical illustration of a degree of extension-flexion of a knee joint during a gait cycle, in accordance with an embodiment;

Fig. 4b is a graphical illustration of a degree of abduction-adduction of a knee joint during a gait cycle, in accordance with an embodiment;

Fig. 4c is a graphical illustration of a degree of internal-external rotation of a knee joint during a gait cycle, in accordance with an embodiment;

Fig. 5a is a graphical illustration of vertical ground reaction forces exerted during a gait cycle, in accordance with an embodiment;

Fig. 5b is a graphical illustration of medial/lateral ground reaction forces exerted during a gait cycle, in accordance with an embodiment; and

Fig. 5c is a graphical illustration of posterior/anterior ground reaction forces exerted during a gait cycle, in accordance with an embodiment.

[0040] It will be noted that throughout the appended drawings, like features are identified by like reference numerals.

DETAILED DESCRIPTION

[0041] There will now be described in reference to the appended drawings, an evaluation and diagnosis apparatus and method for evaluating a knee joint to detect knee joint pathologies and/or injuries. The described apparatus and method are adapted to quantify: (i) a function of a knee joint movement, (ii) an impact of a pathology and/or an injury on biomechanics of the knee joint; (iii) an impact of a given treatment on the knee joint biomechanical function.

[0042] In addition, the presently described apparatus and method does not require such advance input on a probable problem to be found, which is contrary to currently available evaluation apparatuses and methods. These are typically limited in that they do require advance input as to probable classes into which a given problem for a knee joint to be evaluated will fall, in order to perform a multi-classification (i.e. identify that the problem falls within one or more of such multiple classes).

[0043] Referring now to the drawings, and more particularly to Fig. 1b, there is shown a typical patient **90,** here a human, whereby knee joint kinematic data is collected using a three-dimensional kinematic data sensor device **92** which is worn by the patient **90** over a knee joint. The sensor device **92** is non-invasive and remains on a surface of the skin of the patient **90.** Many types of sensor devices can be used for such purposes. Examples include optical tracking devices; electromagnetic tracking devices and accelerometers.

[0044] As seen in Figures. 1a and 1b, a knee joint is able to move according to three different planes of motion; each of these allowing two degrees of freedom.

[0045] First plane of motion - Flexion-Extension illustrated by arrow M1: This motion refers to the capacity of movement of the knee joint to move the leg towards (flexion) the back of the thigh, and away (extension).

[0046] Second plane of motion - Abduction-Adduction illustrated by arrow M2: This motion refers to the capacity of movement of the knee joint to arc the leg towards a center axis of the body. As an example, an Abduction-Adduction planecan be apparent in a subject who has a "cowboy-like" demeanour, although this type of movement is typically subtle in most human patients.

[0047] Third plane of motion - Internal-External Rotation illustrated by arrow M3: This motion refers to the capacity of movement of the knee joint to rotate about itself (or about an axis of rotation substantially along a longitudinal plane of the leg).

[0048] The sensor device monitors kinematic data reflective of each of the three above described plane of motion. The kinematic data gathered is thus indicative of three planes of movement (6 degrees of freedom) per knee joint of a patient.

[0049] As most knee joint disorders (be it knee osteoarthritis, anterior cruciate ligament rupture, meniscal tear, patello-femoral syndrome) have a concrete impact on knee joint movement, these can be associated to specific kinematic data gathered during knee movement. Inversely, an abnormal knee joint movement is determined by kinematic data recordings and in some instances is also informative of a patient's predisposition towards developing a given knee joint injury and/or pathology.

[0050] A database stores normative biomechanical profiles each associated with a given knee joint pathology and/or injury. Each of these normative profiles is preloaded based on kinematic data gathered from various patients. For a given normative profile, various diagnoses made using a set of various means, such as imagery and expert evaluation, are correlated with one another in order to ensure that the final diagnosis associated to the normative profile is accurate. In this way, the normative profiles are each associated to a type of injury and/or pathology.

[0051] Upon comparison of the normative profiles to a biomechanical profile of a knee joint of a patient, at least a knee joint problem classification is achieved directly and automatically without use of imagery, and according to a quantified level of reliability, as described in greater detail below.

[0052] Fig. 2 is a schematic illustration of an apparatus for identifying and characterizing a knee joint problem, in accordance with another embodiment. The apparatus **100** has a set of sensors **102** in communication with a processing device **104,** a memory **106,** a graphical user interface (GUI) 108, a display device **110,** and a database **112.**

[0053] According to the invention, the sensors **102** have tracking devices (not shown) to track position, speed and acceleration of various parts of the knee joint during a movement of the knee joint to generate kinematic data associated to the knee joint movement as it is being performed. In this case, the sensors **102** are sensing devices adapted to be attached to a patient's knee joint or other portion of the limb under evaluation. According to the invention, the sensors **102** are force sensors positioned so as to measure either one or a combination of kinetic data and ground reaction forces during movement, as later described. Other examples of sensors **102** include, but are not limited to, cameras, accelerometers and gyroscopes which are respectively positioned, for example, on the femur and the tibia of the patient. In any given case, the sensors **102** generate biomechanical data associated to the movement and as it is performed.

[0054] Knee joint movements include for example, gait, squats, lunges or a combination of these movements. The biomechanical data is representative of the knee joint movement in according to at least one dimension of movement. Once biomechanical data is gathered, or as it is gathered, it is sent from the sensors **102** to the processing device **104,** and optionally stored in the memory **106.**

[0055] Once received at the processing device **104,** either after the movement has passed or during the time the movement is being performed, the biomechanical data is processed in the processing device **104,** in accordance with instructions stored in the memory **106.** Such processing results in a biomechanical profile of the knee joint. The biomechanical profile is generated based on the biomechanical data and is indicative of at least one of the three planes of motion M1, M2 and M3 of the knee joint, as described above in relation to Figs. 1a and 1b.

[0056] Normative profiles are stored in the database **112** in association with at least one class of knee joint problem(s). A class has one or more knee joint problems which are known to be associated to quantifiable effects on the biomechanics of knee joints; and thence on the biomechanical profiles of knee joints.

[0057] If the class defines a single knee joint problem, then the class defines a particular known knee joint injury, pathology or biomechanical deficit of knee joints. If the class regroups various known knee joint problems, then it is associated to a combination of injuries, pathologies and biomechanical deficits, which are for example, generally documented in the medical field as falling under a given particular category of knee joint problems. In one embodiment, the normative profile(s) associated to each class are biomechanical profile(s) which are accepted in the medical field as being indicative of a particular knee joint problem, or a plurality of particular knee joint problems.

[0058] Still referring to Fig. 2, the normative profiles are retrieved from the database **112** by the processing device **104.** The processing device **104** then proceeds by applying a pattern recognition technique on these normative profiles and the biomechanical profile, from which a classification of the biomechanical profile of the knee joint under analysis is made by the processing device **104.**

[0059] The pattern recognition and classification is performed in the processing device **104.** Various types of pattern recognition (also referred to pattern classification) techniques can be used, as per instructions (also referred to as coding) stored in the memory **106.** For example, any computer implemented pattern recognition between the biomechanical profile and the normative profiles is used such as, for example, any type of machine learning technique to provide an automated machine classification and decision-making based on the biomechanical profile. A non-exhaustive list of possible implementations includes: a parametric or a non parametric technique, a neural network, a nearest neighbour classification technique, a projection technique, a decision tree technique, a stochastic method, genetic algorithms and an unsupervised learning and clustering technique.

[0060] The processing device **104** proceeds to classify the biomechanical profile of the knee joint into one of several classes of known knee joint problems, based on results from the pattern recognition technique.

[0061] Once the classification of the biomechanical profile is done, a problem is identified based on the class(es) in which the biomechanical profile has been classified, and the identified problem is outputted by the processing device **104.** More particularly, the problem identified corresponds to the knee joint problem in the class of knee joint problems under which the biomechanical profile has been classified by the processing device **104.** For example, if the biomechanical profile is classified in a class of normative profiles associated to a meniscus tear, then the indentified problem corresponds or at least comprises the meniscus tear. In one instance, the problem identified can in fact combine more than one knee joint problem when the biomechanical profile is classified in a class associated to more than one problem.

[0062] In addition to the normative profiles, the database **112** can store the biomechanical profile for the knee joint, any type of patient-identification data, and the biomechanical data received from the sensors **102.** In one embodiment, the database **112** stores a plurality of sets of normative profiles; each set being associated to a particular class of pathology(ies) and/or injury(ies) and/or biomechanical deficit(s).

[0063] The GUI **108** and the display device **110** are in communication with one another and with the processing device **104** (and in one embodiment, with the memory **106**). The GUI **108** receives either one or a combination of the classification for the knee joint under analysis and the identified problem, whichever appropriate in a specific case. In either case, however, the GUI **108** displays either one or a combination of the classification and the particular problem identified, including a description of the knee joint problem(s) involved,) on the display device **110.** The GUI may also display the biomechanical profile generated from the biomechanical data.

[0064] The GUI allows user interaction such that a particular display setting is activated on the display device **110,** to show either or a combination of: the biomechanical profile, the diagnosis and the normative profile(s) relevant to the problem identified, in accordance with a user preferences.

[0065] Still in reference to Fig. 2, it is noted that in one exemplary construction, the sensors **102** are embodied as a commonly available three-dimensional (3D) knee movement analyser such as the one described in United States patent No. 7,291,119, and having a set of tracking sensors suited to obtain kinematic data for tibio-femoral movements of a knee joint. The sensors **102** can however be of any type of dynamic 1D, 2D or 3D knee analyzer based on either one or a combination of available technologies such as optical, electromagnetic, accelerometers, which provide for the monitoring of an acceleration, position and speed.

[0066] In addition to the above-described apparatus, it is noted that in one embodiment, the apparatus **100** is adapted to perform any of the below-detailed steps of a method **300** described in relation to Fig. 3. For example, one embodiment of the apparatus **100** is adapted to output a quantified function of the knee joint during the movement (i.e. with respect to time). In the same manner, the apparatus **100** can also be adapted to compare a current biomechanical profile with an older (also referred to as past or previous) biomechanical profile for the same knee joint, and quantify a progression (improvement or degradation) of the problem in the given period between the current and the past biomechanical profiles for example. Other optional functionalities also include sorting a plurality of identified knee joint problems such as pathologies, injuries and biomechanical deficits in terms of their respective degree of importance, priority or combination thereof; normalize the biomechanical data prior to generating and displaying the biomechanical profile; and generating a complete report for a patient's knee joint(s) under analysis.

[0067] It is noted that while the apparatus **100** is described as receiving biomechanical data from the sensors **102,** such biomechanical data represents, in one configuration, only kinematic data. In other implementations, however, the biomechanical data is any one of, or a combination of: kinematic data, kinetic data and ground reaction forces. In one implementation, additional data such as patient data, professional diagnostic data, and clinical information is received as well. It is noted that the apparatus **100** is able to rely only on the kinematic data in order to provide for the herein described functionalities (i.e. in one configuration, the kinematic data is a sole input to the processing device **104**).

[0068] Fig. 3 shows a flow chart of a method **300** for evaluating a knee joint and identifying a knee joint problem, in accordance with an embodiment.

[0069] In step **302,** biomechanical data is received from a sensor. The biomechanical data is representative of a movement performed by a knee joint, in accordance with one of the three planes of movement defined above in reference to Fig. 1a-1b. In one configuration, the biomechanical data is received while the movement is being performed by the knee joint.

[0070] In step **304,** a biomechanical profile is generated based on the biomechanical data received. The biomechanical profile is indicative of at least one of the three planes of motion of the knee joint as the movement is performed.

[0071] In step **306,** the biomechanical profile is classified in at least one class of knee joint problem(s) using a pattern recognition technique applied to at least one set of normative profiles. The set of normative biomechanical profiles are pre-associated to one of multiple classes of knee joint problems (i.e. when there is more than one set, each set is associated to a single class).

[0072] In one embodiment, step **306** involves comparing the biomechanical profile to the set of normative biomechanical profiles. In one configuration, a correlation model is used.

[0073] As described also hereinabove, a class of knee joint problem(s) defines one or more known knee joint problem known to have an effect on the biomechanics of the knee joint (i.e. the biomechanical profile will be reflective of one or more of the knee joint problems). If the class is associated to a single knee joint problem, then the class defines a particular known knee joint injury, pathology or biomechanical deficit associated to knee joints. If the class regroups various known knee joint problems, then the class is associated to a combination of either one of injuries, pathologies and biomechanical deficits for example. Such problems are generally documented in the medical field as falling under a given particular type of knee joint problem. In some instances, one biomechanical profile is classified in multiple classes, in which case the knee joint has deficiencies encompassing multiple types of knee joint problems.

[0074] In step **308,** the knee joint problem(s) proper to the particular knee joint under analysis is(are) identified based on the results of step **306.** Since each one of the multiple classes is indicative of at least one particular knee joint problem (i.e. pathology, injury or biomechanical deficit), the at least one class according to which the biomechanical profile is classified is indicative of a particular knee joint problem for the knee joint. The identification of such knee joint problem corresponds is performed by a computer device in accordance to this method **300** and thereby provides an assistance in medical diagnosis.

[0075] In step **310,** the identified problem(s) is(are) archived for further analysis, reporting or display on an output of any type, such as email or other network-based notification addressed to authenticated users for example.

[0076] In one embodiment where step **306** involves classifying the biomechanical profile into one of the multiple classes being associated to multiple knee joint problems, the problem identified in step **308** comprises more than one problem. In such a case, the method **300** involves another optional step (not illustrated in Fig. 3) of sorting the multiple identified problems according to a set of priority levels pre-defined for a list of possible knee joint problems, Alternatively or additionally, the sorting is done according to a respective degree of severity associated with each one of the diagnosed knee joint problems.

[0077] In one configuration, the set of priority levels are established by a user entering the levels manually via user interaction with a graphical user interface (GUI). In another configuration, the levels are set by default in a processing device implementing the method **300.**

[0078] In order to evaluate the degree of severity of a diagnosed knee joint problem, it is first noted that the one or more normative biomechanical profiles associated with the diagnosed knee joint problem provide, in one configuration, a data range within which the patient's biomechanical profile is determined to fit via the pattern recognition in step **306.** The shape of the patient's biomechanical profile fitting within this range is analyzed in order to provide for the degree of severity. In a specific case where the patient's biomechanical profile has a shape defined within an extremity of the data range in the normative profile, for example, the degree of severity is said to be higher than if the shape were defined within a mid section of the data range. Other techniques for determining the degree of severity can also be used based on any kind of error analysis technique.

[0079] In one embodiment, step **304** also involves quantifying a function of the knee joint with respect to a time elapsed during the movement.

[0080] In one implementation, the pattern recognition technique applied in step **306** is any type of computer implemented pattern recognition which includes for example machine learning techniques enabling automated machine classification and decision-making based on the biomechanical profile and normative profiles

[0081] The classifying in step **306,** involves in one embodiment, determining an amount of similarity (also referred to as adherence). The amount of similarity is relied upon for the identification step **308.** As the amount of similarity is also indicative of a degree of reliability in the classifying performed in step **308,** it also serves as a reliability indication.

[0082] Still in reference to Fig. 3, it is noted that in addition to step **310** as illustrated, the method **300** involves in one example the displaying of a graphical user interface (GUI) which allows user interaction. For example, the user is able to enter preferences, or request a particular type of display of particular data.

[0083] In addition, the method **300** also optionally involves displaying the biomechanical profile in accordance with a given format. The format can be as per a user entered preference(s) or set by default. In one embodiment, the displaying optionally involves generating a set of graphical illustrations to represent the data according to at least one of the three planes of motion as they are sensed by the motion sensor during the movement. In one embodiment, the planes of motion are provided in terms of degrees, and the time elapsed during the movement of the knee joint is provided in terms of percentage of the movement performed. Examples of graphical illustrations are provided by Fig. 4a, 4b and 4c, which respectively illustrate a graph of plane degrees versus percentage of elapsed movement (here a gait cycle); for each one of the three plane of motion M1, M2 and M3 as described above with respect to Fig. 1. More particularly, Fig. 4a shows the flexion-extension plane M1; Fig. 4b shows the abduction-adduction plane M2; and Fig. 4b shows the internal-external rotation plane M3.

[0084] Referring back to Fig. 3 and the embodiment where a GUI is displayed, a user can interact with the GUI to optionally select and enlarge a portion of the biomechanical profile for display. This option allows the user to visualize a particular degree of angular motion at a particular time during the movement; which is helpful in detecting relatively subtle knee joint motions.

[0085] Still with respect to the method **300,** step **302** involves receiving as biomechanical data, at least one of kinematic, kinetic data and data reflective of ground reaction forces. The kinetic data and ground reaction force data are received from sensing devices such as force plates and treadmills equipped with sensing instruments.

[0086] In one implementation, step **302** optionally involves receiving additional data such as patient information data, and clinical information data such as data entered into the system by a health practitioner (or retrieved from a database storing such patient and, or clinical data related to the patient). Patient data can comprise patient identification while clinical data can comprise previous diagnosis associated with the patient, or any other notes entered by a health care specialist for example. While other sources of data can be received in step **302,** the method **300** and all other optional steps described herein, are achievable using as a sole input, kinematic data received from a set of motion sensors.

[0087] When step **302** involves receiving kinetic data, step **304** involves displaying the biomechanical profile with the kinetic data is optionally displayed within the profile. Similarly for ground reaction forces. In one embodiment, the displaying of the kinetic data or ground reaction forces involves generating a set of graphical illustrations according for example to three types of forces in play during the performance of the movement. In one embodiment, these forces respectively correspond to a vertical force, a lateral-medial force and a posterior-anterior force; as per the graphs illustrated in Figures 5a, 5b and 5c respectively. In the illustrated graphs of Figures 5a, 5b and 5c, the amount of ground reaction force is provided as a percentage of the patient's body weight (BW), while the time elapsed during the movement (here a gait cycle) is provided in terms of percentage of completion of the movement.

[0088] In addition to the above, the method **300** can also involve another step whereby the biomechanical profile is compared to a past biomechanical profile generated for the same knee joint. Based on such a comparison, an effect of a treatment is quantified in order to give an evaluation of a success or a failure of a given treatment. In the same way, a degradation/progression of a knee joint condition in time can be evaluated from a similar comparison. In one example, such a comparison involves superimposing past and current profiles (or pre and post treatment profiles).

[0089] Still in relation to Fig. 3, step **304** optionally involves normalizing the biomechanical data received in step **302** in order to generate normalized biomechanical profile for the knee joint. Alternatively, this option can be performed in or after step **310** prior to displaying the biomechanical profile in accordance with a given format, whereby the formatting involves the normalizing of the data.

[0090] Finally, it is noted that in one embodiment, the method **300** can also provide for the generating of a report. The report is built to include information such as patient data, the biomechanical profile (formatted as per a user's likings), and data pertaining to the identified problem as obtained from the performing of the method **300.** In one instance, kinetic data, data on ground reaction forces, or a combination thereof, also is also provided in the report, optionally formatted as per a user's likings.

[0091] Other clinical data can also be part of the report, such as health practitioner notes and indications to the intention of the patient, or other practitioners.

[0092] The following provides examples of data which can be found in typical reports: a name of a conducting health professional; a date of consultation; a name of a patient; names of other individuals involved with either one of the consultation and report; a brief description of the context (e.g. an age of the patient; left, right knee joint pain; details on any injury; date and description of an incident if relevant; type and date of previous examinations when applicable; previous relevant knee joint injuries and/or pathologies when applicable); type of movement which was performed during the evaluation; descriptive summary of biomechanical deficits noted from the kinematic data and as reflected in the biomechanical profile (for example: a deficit in flexion movement during gait loading phase, limited knee joint flexion during push-off phase; important internal tibial rotation during loading phase); any other descriptive summary of biomechanical deficits noted via analysis of data on forces in play (i.e. kinetic or ground reaction forces, or combination thereof), such as loading phase time, forces involves with respect to one knee compared to the other knee (when data is available), deficits in breaking and pushing; other notes regarding video data (when provided in the profile) - i.e. for example any signs of limping; conclusions of post-examination; diagnosis(es) and recommendations of treatment(s).

[0093] According to the invention, a computer-readable media is provided having instructions for implementing a processor device to perform the above-described embodiments of the method 300.

[0094] Now referring to Fig. 4a, there is shown a graphical illustration of a degree of extension-flexion of one knee joint of a patient during a gait cycle, compared to a healthy range, in accordance with an embodiment. Fig. 4b is another graphical illustration of a degree of abduction-adduction of one knee joint of a patient during a gait cycle, in accordance with an embodiment; and Fig. 4c is yet another graphical illustration of a degree of internal-external rotation of one knee joint of a patient during a gait cycle, in accordance with an embodiment. In all three figures, it is noted that the gray range provides an indication of a healthy knee joint movement as seen in typical healthy subjects. The full line represents the mean angular motion for the patient's knee joint and the dashed lines represent the standard deviation with respect to the movement of a healthy knee joint.

[0095] The report is generated to include analytical comments regarding graphs such as those in Figures 4a, 4b and 4c. For example, from Fig. 4a it is possible to identify degrees of plane motions for each phase in the movement, from the initial contact of the foot with the ground (if the movement is gait), the loading phase, the stance phase, the push-off phase, to the swing phase). Total amplitude of the angular motion is also provided in terms of degrees, which is qualified as falling either in a healthy or unhealthy range.

[0096] Similar analytical comments are provided in the report regarding kinetic data (when applicable), as provided by graphical illustrations such as those of Figures 5a, 5b and 5c: Fig. 5a is a graphical illustration of vertical ground reaction forces exerted on a patient during a gait cycle, in accordance with an embodiment; Fig. 5b is a graphical illustration of medial/lateral ground reaction forces exerted on a patient during a gait cycle, in accordance with an embodiment.; and Fig. 5c is a graphical illustration of posterior/anterior ground reaction forces exerted on a patient during a gait cycle, in accordance with an embodiment. All forces are indicated as a percentage of the patient's body weight (BW) while time is expressed as a percentage of completion of the gait cycle).

[0097] While preferred embodiments have been described above and illustrated in the accompanying drawings, it will be evident to those skilled in the art that modifications may be made therein without departing from the essence of this disclosure. Such modifications are considered as possible variants comprised in the scope of the disclosure.

Claims

1. A non-transitory computer readable media storing instructions for implementing a processor (104) to identify a problem of a knee joint, the instructions comprising coding for implementing the processor (104) to:

    receive biomechanical data from sensors (102) worn by the patient and sensing devices such as force plates or treadmills equipped with sensing instruments, the biomechanical data being representative of a movement of the knee joint during complete cycles of the movement of the knee joint;
    further **characterized in** implementing the processor (104) to:
    generate a continuous biomechanical profile based on the biomechanical data, the continuous biomechanical profile comprising a continuous curve representative of the biomechanical data for the knee joint as a function of a percentage of the complete cycles of the movement of the knee joint, where each input represents a percentage of completion of the complete cycle of the movement of the knee joint and where outputs represent:

        a degree of extension-flexion of the knee joint of the patient corresponding to the percentage of completion of the complete cycle of the knee joint;
        a degree of abduction-adduction of the knee joint of the patient corresponding to the percentage of completion of the complete cycle of the knee joint;
        a degree of internal-external rotation of the knee joint of the patient corresponding to the percentage of completion of the complete cycle of the knee joint;
        a vertical ground reaction force exerted on the patient corresponding to the percentage of completion of the complete cycle of the knee joint;
        a medial/lateral ground reaction force exerted on the patient corresponding to the percentage of completion of the complete cycle of the knee joint; and
        a posterior/anterior ground reaction force exerted on the patient corresponding to the percentage of completion of the complete cycle of the knee joint;

    classify the continuous biomechanical profile of the knee joint in one of multiple classes of knee joint problems by applying a pattern recognition technique on the continuous biomechanical profile and a normative biomechanical profile asso-

ciated to the one of the multiple classes, each one of the multiple classes corresponding to at least one knee joint problem comprising at least one of an injury, a pathology and a biomechanical deficit;
based on the classifying, identify the problem as comprising the at least one knee joint problem of the one of the multiple classes; and
archive the problem identified in a storing device in communication with the processing device to make the problem accessible during consultation.

2. The non-transitory computer readable media of claim 1, wherein the classifying comprises comparing the biomechanical profile to the set of normative biomechanical profiles.

3. The non-transitory computer readable media of claim 1 or 2, wherein the receiving comprises receiving the biomechanical data as the movement is being performed by the knee joint.

4. The non-transitory computer readable media of any one of claims 1 to 3, wherein the generating of the biomechanical profile comprises quantifying a function of the knee joint versus a time elapsed during the movement.

5. The non-transitory computer readable media of any one of claims 1 to 4, wherein the pattern recognition technique comprises at least one of: a neural network, a nearest neighbour classification technique, a projection technique, and a decision tree technique.

6. The non-transitory computer readable media of any one of claims 1 to 5, further comprising comparing the biomechanical profile to a past biomechanical profile generated for the same knee joint at an earlier time; and quantifying at least one of: a progression of the problem and an effect of a treatment performed on the knee joint, based on the classifying.

7. The non-transitory computer readable media of any one of claims 1 to 6, wherein the receiving the biomechanical data comprises receiving at least one of kinematic data; kinetic data; and data of ground reaction forces.

8. The non-transitory computer readable media of any one of claims 1 to 7, wherein each one of the multiple classes is indicative of at least one of: a knee joint injury; a knee joint pathology; a class of knee joint pathologies; and a class of knee joint injuries.

9. The non-transitory computer readable media of claim 8, wherein the identifying comprises identifying the problem as comprising at least two knee joint problems, the one of the multiple classes being associated to the at least two knee joint problems.

10. The non-transitory computer readable media of claim 9, further comprising sorting the at least two knee joint problems based on a respective degree of severity for each one of the at least two knee joint problems.

11. The non-transitory computer readable media of any one of claims 1 to 10, wherein the classifying comprises determining an amount of similarity between the biomechanical profile and at least one of the set of normative biomechanical profiles.

12. The non-transitory computer readable media of claim 11, further comprising at least one of: generating a report to include an identification of the problem; and displaying the report with the identification of the problem, the identification comprising at least one of: a name for the at least one knee joint problem; the amount of similarity; and the biomechanical profile with an indication of a problematic area associated with the at least one knee joint problem.

13. The non-transitory computer readable media of any one of claims 1 to 12, further comprising generating a recommendation based on a pre-established treatment associated to the at least one knee joint problem.

14. An apparatus for identifying and characterizing a problem of a knee joint, the apparatus comprising:

sensors (102) for wearing by the patient and sensing devices such as force plates or treadmills equipped with sensing instruments, the sensors (102) and sensing devices for gathering biomechanical data representative of a movement of a knee joint during complete cycles of the movement of the knee joint;
a processor (104) in communication with the sensors (102) and sensing devices; and
a memory device (106) accessible by the processor (104), the memory device (106) storing instructions for retrieval by the processor (104) and **characterized in** having the processor (104) to implement the processor (104) to:

receive the biomechanical data from the sensors (102) and sensing devices;
generate a continuous biomechanical profile based on the biomechanical data the continuous biomechanical profile comprising a continuous curve representative of the biomechanical data for the knee joint as a function of a percentage of the complete cy-

cles of the movement of the knee joint, where each input represents a percentage of completion of the complete cycle of the movement of the knee joint and where outputs represent:

a degree of extension-flexion of the knee joint of the patient corresponding to the percentage of completion of the complete cycle of the knee joint;
a degree of abduction-adduction of the knee joint of the patient corresponding to the percentage of completion of the complete cycle of the knee joint;
a degree of internal-external rotation of the knee joint of the patient corresponding to the percentage of completion of the complete cycle of the knee joint;
a vertical ground reaction force exerted on the patient corresponding to the percentage of completion of the complete cycle of the knee joint;
a medial/lateral ground reaction force exerted on the patient corresponding to the percentage of completion of the complete cycle of the knee joint; and
a posterior/anterior ground reaction force exerted on the patient corresponding to the percentage of completion of the complete cycle of the knee joint;

classify the continuous biomechanical profile of the knee joint in one of multiple classes of knee joint problems by applying a computer implemented pattern recognition technique on the continuous biomechanical profile and a normative biomechanical profile associated to the one of the multiple classes, each one of the multiple classes corresponding to at least one knee joint problem comprising at least one of an injury, a pathology and a biomechanical deficit;
based on the classifying, identify the problem as comprising the knee joint problem of the one of the multiple classes; and
archive the problem identified to allow retrieval of the problem during a medical consultation.

Patentansprüche

1. Nichtflüchtiges computerlesbares Medium, das Anweisungen speichert, um einen Prozessor (104) zu implementieren, um ein Problem eines Kniegelenks zu identifizieren, wobei die Anweisungen Codierung zum Implementieren des Prozessors (104) für Folgendes umfassen:

Empfangen von biomechanischen Daten von Sensoren (102), die von dem Patienten getragen werden, und Erfassungsvorrichtungen, wie zum Beispiel Kraftplatten oder Laufbändern, die mit Erfassungsinstrumenten ausgestattet sind, wobei die biomechanischen Daten eine Bewegung des Kniegelenks während vollständiger Zyklen der Bewegung des Kniegelenks repräsentieren;
ferner **gekennzeichnet durch** das Implementieren des Prozessors (104) für Folgendes:
Erzeugen eines durchgehenden biomechanischen Profils basierend auf den biomechanischen Daten, wobei das durchgehende biomechanische Profil eine durchgehende Kurve umfasst, die die biomechanischen Daten für das Kniegelenk in Abhängigkeit eines Prozentsatzes der vollständigen Zyklen der Bewegung des Kniegelenks repräsentiert, wobei jede Eingabe einen Prozentsatz des Abschlusses des vollständigen Zyklus der Bewegung des Kniegelenks repräsentiert und wobei Ausgaben Folgendes repräsentieren:

einen Grad der Extension-Flexion des Kniegelenks des Patienten entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;
einen Grad der Abduktion-Adduktion des Kniegelenks des Patienten entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;
einen Grad der internen-externen Drehung des Kniegelenks des Patienten entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;
eine vertikale Bodenreaktionskraft, die auf den Patienten ausgeübt wird, entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;
eine mediale/laterale Bodenreaktionskraft, die auf den Patienten ausgeübt wird, entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks; und
eine posteriore/anteriore Bodenreaktionskraft, die auf den Patienten ausgeübt wird, entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;

Klassifizieren des durchgehenden biomechanischen Profils des Kniegelenks in einer von mehreren Klassen von Kniegelenkproblemen durch Anwenden einer Mustererkennungstechnik an dem durchgehenden biomechanischen Profil

und einem normativen biomechanischen Profil in Verbindung mit der einen der mehreren Klassen, wobei jede der mehreren Klassen zumindest einem Kniegelenkproblem entspricht, das zumindest eines von einer Verletzung, einer Pathologie und einem biomechanischen Defizit umfasst;
basierend auf dem Klassifizieren, Identifizieren des Problems als das zumindest eine Kniegelenkproblem der einen der mehreren Klassen umfassend; und
Archivieren des identifizierten Problems in einer Speichervorrichtung in Kommunikation mit der Verarbeitungsvorrichtung, um das Problem während der Konsultation zugänglich zu machen.

2. Nichtflüchtiges computerlesbares Medium nach Anspruch 1, wobei das Klassifizieren das Vergleichen des biomechanischen Profils mit dem Satz an normativen biomechanischen Profilen umfasst.

3. Nichtflüchtiges computerlesbares Medium nach Anspruch 1 oder 2, wobei das Empfangen das Empfangen der biomechanischen Daten, während die Bewegung durch das Kniegelenk durchgeführt wird, umfasst.

4. Nichtflüchtiges computerlesbares Medium nach einem der Ansprüche 1 bis 3, wobei das Erzeugen des biomechanischen Profils das Quantifizieren einer Abhängigkeit des Kniegelenks von einer während der Bewegung vergangenen Zeit umfasst.

5. Nichtflüchtiges computerlesbares Medium nach einem der Ansprüche 1 bis 4, wobei die Mustererkennungstechnik zumindest eines des Folgenden umfasst: ein neuronales Netzwerk, eine Nächster-Nachbar-Klassifizierungstechnik, eine Projektionstechnik und eine Entscheidungsbaumtechnik.

6. Nichtflüchtiges computerlesbares Medium nach einem der Ansprüche 1 bis 5, ferner umfassend das Vergleichen des biomechanischen Profils mit einem vergangenen biomechanischen Profil, das zu einem früheren Zeitpunkt für dasselbe Kniegelenk erzeugt wird; und Quantifizieren von zumindest einem des Folgenden: einer Progression des Problems und einer Auswirkung einer an dem Kniegelenk durchgeführten Behandlung basierend auf dem Klassifizieren.

7. Nichtflüchtiges computerlesbares Medium nach einem der Ansprüche 1 bis 6, wobei das Empfangen der biomechanischen Daten das Empfangen von zumindest einem von kinematischen Daten; kinetischen Daten; und Daten von Bodenreaktionskräften umfasst.

8. Nichtflüchtiges computerlesbares Medium nach einem der Ansprüche 1 bis 7, wobei jede der mehreren Klassen zumindest eines des Folgenden angibt: eine Kniegelenkverletzung; eine Kniegelenkpathologie; eine Klasse an Kniegelenkpathologien; und eine Klasse an Kniegelenkverletzungen.

9. Nichtflüchtiges computerlesbares Medium nach Anspruch 8, wobei das Identifizieren das Identifizieren des Problems als zumindest zwei Kniegelenkprobleme umfassend umfasst, wobei die eine der mehreren Klassen mit den zumindest zwei Kniegelenkproblemen verbunden ist.

10. Nichtflüchtiges computerlesbares Medium nach Anspruch 9, ferner umfassend das Sortieren der zumindest zwei Kniegelenkprobleme basierend auf einem jeweiligen Schweregrad für jedes der zumindest zwei Kniegelenkprobleme.

11. Nichtflüchtiges computerlesbares Medium nach einem der Ansprüche 1 bis 10, wobei das Klassifizieren das Bestimmen einer Menge an Ähnlichkeit zwischen dem biomechanischen Profil und zumindest einem aus dem Satz an normativen biomechanischen Profilen umfasst.

12. Nichtflüchtiges computerlesbares Medium nach Anspruch 11, ferner umfassend zumindest eines des Folgenden: Erzeugen eines Berichtes, der eine Identifizierung des Problems enthält; und Anzeigen des Berichtes mit der Identifizierung des Problems, wobei die Identifizierung zumindest eines des Folgenden umfasst: einen Namen für das zumindest eine Kniegelenkproblem; die Menge an Ähnlichkeit; und das biomechanische Profil mit einer Angabe eines problematischen Bereichs in Verbindung mit dem zumindest einen Kniegelenkproblem.

13. Nichtflüchtiges computerlesbares Medium nach einem der Ansprüche 1 bis 12, ferner umfassend das Erzeugen einer Empfehlung basierend auf einer zuvor festgelegten Behandlung in Verbindung mit dem zumindest einen Kniegelenkproblem.

14. Vorrichtung zum Identifizieren und Charakterisieren eines Problems eines Kniegelenks, wobei die Vorrichtung Folgendes umfasst:

Sensoren (102) zum Tragen durch den Patienten und Erfassungsvorrichtungen, wie zum Beispiel Kraftplatten oder Laufbänder, die mit Erfassungsinstrumenten ausgestattet sind, wobei die Sensoren (102) und die Erfassungsvorrichtungen dem Sammeln von biomechanischen Daten dienen, die eine Bewegung eines Kniegelenks während vollständiger Zyklen der Bewegung des Kniegelenks repräsentieren;

einen Prozessor (104) in Kommunikation mit den Sensoren (102) und Erfassungsvorrichtungen; und
eine Speichervorrichtung (106), die durch den Prozessor (104) zugänglich ist, wobei die Speichervorrichtung (106) Anweisungen zum Abrufen durch den Prozessor (104) speichert und **dadurch gekennzeichnet ist, dass** der Prozessor (104) dazu gebracht wird, den Prozessor (104) für Folgendes zu implementieren:

Empfangen der biomechanischen Daten von den Sensoren (102) und Erfassungsvorrichtungen;
Erzeugen eines durchgehenden biomechanischen Profils basierend auf den biomechanischen Daten, wobei das durchgehende biomechanische Profil eine durchgehende Kurve umfasst, die die biomechanischen Daten für das Kniegelenk in Abhängigkeit eines Prozentsatzes der vollständigen Zyklen der Bewegung des Kniegelenks repräsentiert, wobei jede Eingabe einen Prozentsatz des Abschlusses des vollständigen Zyklus der Bewegung des Kniegelenks repräsentiert und wobei Ausgaben Folgendes repräsentieren:

einen Grad der Extension-Flexion des Kniegelenks des Patienten entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;
einen Grad der Abduktion-Adduktion des Kniegelenks des Patienten entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;
einen Grad der internen-externen Drehung des Kniegelenks des Patienten entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;
eine vertikale Bodenreaktionskraft, die auf den Patienten ausgeübt wird, entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;
eine mediale/laterale Bodenreaktionskraft, die auf den Patienten ausgeübt wird, entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks; und
eine posteriore/anteriore Bodenreaktionskraft, die auf den Patienten ausgeübt wird, entsprechend dem Prozentsatz des Abschlusses des vollständigen Zyklus des Kniegelenks;

Klassifizieren des durchgehenden biomechanischen Profils des Kniegelenks in einer von mehreren Klassen an Kniegelenkproblemen durch Anwenden einer computerimplementierten Erkennungstechnik auf das durchgehende biomechanische Profil und ein normatives biomechanisches Profil in Verbindung mit der einen der mehreren Klassen, wobei jede der mehreren Klassen zumindest einem Kniegelenkproblem entspricht, das zumindest eines von einer Verletzung, einer Pathologie und einem biomechanischen Defizit umfasst;
basierend auf dem Klassifizieren, Identifizieren des Problems als das Kniegelenkproblem der einen der mehreren Klassen umfassend; und
Archivieren des identifizierten Problems, um Abrufen des Problems während einer medizinischen Konsultation zu ermöglichen.

Revendications

1. Support lisible par ordinateur non transitoire stockant des instructions pour mettre en œuvre un processeur (104) afin d'identifier un problème d'une articulation du genou, les instructions comprenant le codage pour la mise en œuvre du processeur (104) afin de :

recevoir des données biomécaniques à partir de capteurs (102) portés par le patient et de dispositifs de détection comme des plateformes de force ou des tapis roulants équipés d'instruments de détection, les données biomécaniques étant représentatives d'un mouvement de l'articulation du genou pendant des cycles complets du mouvement de l'articulation du genou ;
caractérisé en outre par la mise en œuvre du processeur (104) afin de :
générer un profil biomécanique continu sur la base des données biomécaniques, le profil biomécanique continu comprenant une courbe continue représentative des données biomécaniques pour l'articulation du genou en fonction d'un pourcentage des cycles complets du mouvement de l'articulation du genou, où chaque entrée représente un pourcentage d'achèvement du cycle complet du mouvement de l'articulation du genou et où les sorties représentent :

un degré d'extension-flexion de l'articulation du genou du patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;
un degré d'abduction-adduction de l'articu-

lation du genou du patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;
un degré de rotation interne-externe de l'articulation du genou du patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;
une force de réaction verticale du sol exercée sur le patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;
une force de réaction médiane/latérale du sol exercée sur le patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ; et
une force de réaction postérieure/antérieure du sol exercée sur le patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;

classifier le profil biomécanique continu de l'articulation du genou dans une de multiples classes de problèmes d'articulation du genou par l'application d'une technique de reconnaissance de formes sur le profil biomécanique continu et un profil biomécanique normatif associé à l'une des multiples classes, chacune des multiples classes correspondant à au moins un problème d'articulation du genou comprenant au moins un d'une blessure, d'une pathologie et d'un déficit biomécanique ;
sur la base de la classification, identifier le problème comme comprenant l'au moins un problème d'articulation du genou de l'une des multiples classes ; et
archiver le problème identifié dans un dispositif de stockage en communication avec le dispositif de traitement afin de rendre le problème accessible lors d'une consultation.

2. Support lisible par ordinateur non transitoire selon la revendication 1, dans lequel la classification comprend la comparaison du profil biomécanique à l'ensemble de profils biomécaniques normatifs.

3. Support lisible par ordinateur non transitoire selon la revendication 1 ou 2, dans lequel la réception comprend la réception des données biomécaniques tandis le mouvement est effectué par l'articulation du genou.

4. Support lisible par ordinateur non transitoire selon l'une quelconque des revendications 1 à 3, dans lequel la génération du profil biomécanique comprend la quantification d'une fonction de l'articulation du genou par rapport à un temps écoulé pendant le mouvement.

5. Support lisible par ordinateur non transitoire selon l'une quelconque des revendications 1 à 4, dans lequel la technique de reconnaissance de formes comprend au moins un de : un réseau neuronal, une technique de classification du plus proche voisin, une technique de projection, et une technique d'arbre de décision.

6. Support lisible par ordinateur non transitoire selon l'une quelconque des revendications 1 à 5, comprenant en outre la comparaison du profil biomécanique à un profil biomécanique passé généré pour la même articulation du genou à un moment antérieur ; et la quantification d'au moins un de : une progression du problème et un effet d'un traitement effectué sur l'articulation du genou, sur la base de la classification.

7. Support lisible par ordinateur non transitoire selon l'une quelconque des revendications 1 à 6, dans lequel la réception des données biomécaniques comprend la réception d'au moins une de données cinématiques ; de données cinétiques ; et de données de forces de réaction du sol.

8. Support lisible par ordinateur non transitoire selon l'une quelconque des revendications 1 à 7, dans lequel chacune des multiples classes indique au moins une de : une blessure de l'articulation du genou ; une pathologie de l'articulation du genou ; une classe de pathologies de l'articulation du genou ; et une classe de blessures de l'articulation du genou.

9. Support lisible par ordinateur non transitoire selon la revendication 8, dans lequel l'identification comprend l'identification du problème comme comprenant au moins deux problèmes d'articulation du genou, l'une des multiples classes étant associée aux au moins deux problèmes d'articulation du genou.

10. Support lisible par ordinateur non transitoire selon la revendication 9, comprenant en outre le tri des au moins deux problèmes d'articulation du genou sur la base d'un degré de gravité respectif pour chacun des au moins deux problèmes d'articulation du genou.

11. Support lisible par ordinateur non transitoire selon l'une quelconque des revendications 1 à 10, dans lequel la classification comprend la détermination d'un degré de similarité entre le profil biomécanique et au moins un de l'ensemble de profils biomécaniques normatifs.

12. Support lisible par ordinateur non transitoire selon la revendication 11, comprenant en outre au moins un de : la génération d'un rapport pour inclure une identification du problème ; et l'affichage du rapport avec l'identification du problème, l'identification comprenant au moins un de : un nom pour l'au moins un problème d'articulation du genou ; le degré de similarité ; et le profil biomécanique avec une indication d'une zone problématique associée à l'au moins un problème d'articulation du genou.

13. Support lisible par ordinateur non transitoire selon l'une quelconque des revendications 1 à 12, comprenant en outre la génération d'une recommandation sur la base d'un traitement préétabli associé à l'au moins un problème d'articulation du genou.

14. Appareil pour identifier et caractériser un problème d'articulation du genou, l'appareil comprenant :

des capteurs (102) destinés à être portés par le patient et des dispositifs de détection comme des plateformes de force ou des tapis roulants équipés d'instruments de détection, les capteurs (102) et les dispositifs de détection étant destinés à recueillir des données biomécaniques représentatives d'un mouvement d'une articulation du genou pendant des cycles complets du mouvement de l'articulation du genou ;
un processeur (104) en communication avec les capteurs (102) et les dispositifs de détection ; et
un dispositif de mémoire (106) accessible par le processeur (104), le dispositif de mémoire (106) stockant des instructions pour la récupération par le processeur (104) et **caractérisé par** le fait d'avoir le processeur (104) pour mettre en œuvre le processeur (104) afin de :

recevoir les données biomécaniques des capteurs (102) et des dispositifs de détection ;
générer un profil biomécanique continu sur la base des données biomécaniques, le profil biomécanique continu comprenant une courbe continue représentative des données biomécaniques pour l'articulation du genou en fonction d'un pourcentage des cycles complets du mouvement de l'articulation du genou, où chaque entrée représente un pourcentage d'achèvement du cycle complet du mouvement de l'articulation du genou et où les sorties représentent :

un degré d'extension-flexion de l'articulation du genou du patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;
un degré d'abduction-adduction de l'articulation du genou du patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;
un degré de rotation interne-externe de l'articulation du genou du patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;
une force de réaction verticale du sol exercée sur le patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;
une force de réaction médiane/latérale du sol exercée sur le patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ; et
une force de réaction postérieure/antérieure du sol exercée sur le patient correspondant au pourcentage d'achèvement du cycle complet de l'articulation du genou ;

classifier le profil biomécanique continu de l'articulation du genou dans une de multiples classes de problèmes d'articulation du genou par l'application d'une technique de reconnaissance de formes mise en œuvre par ordinateur sur le profil biomécanique continu et un profil biomécanique normatif associé à l'une des multiples classes, chacune des multiples classes correspondant à au moins un problème d'articulation du genou comprenant au moins un d'une blessure, d'une pathologie et d'un déficit biomécanique ;
sur la base de la classification, identifier le problème comme comprenant le problème d'articulation du genou de l'une des multiples classes ; et
archiver le problème identifié afin de permettre la récupération du problème lors d'une consultation médicale.

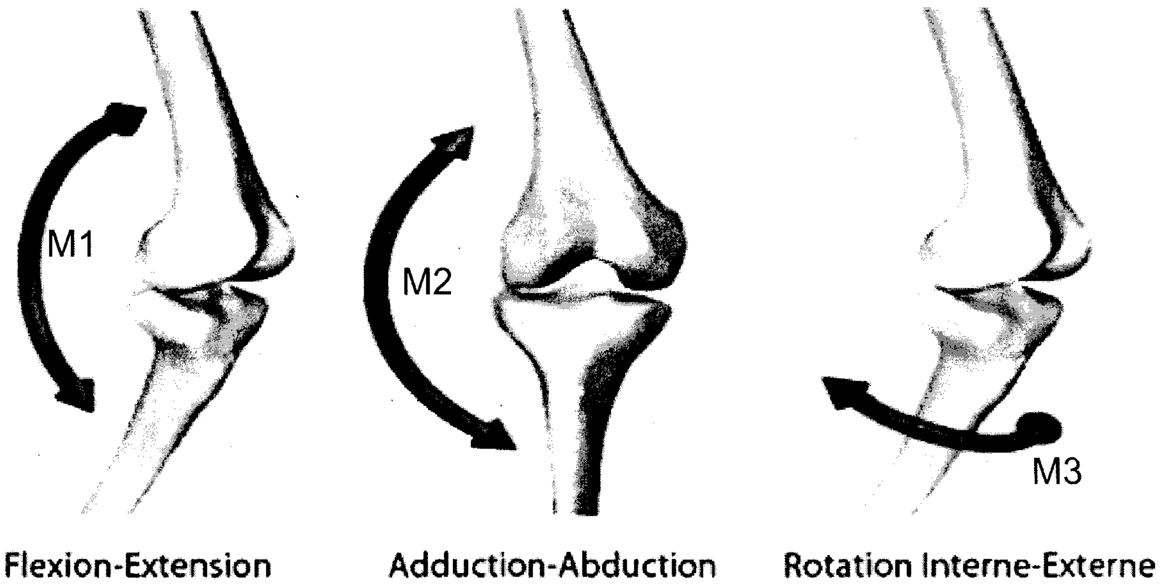

Fig. 1a (Prior Art)

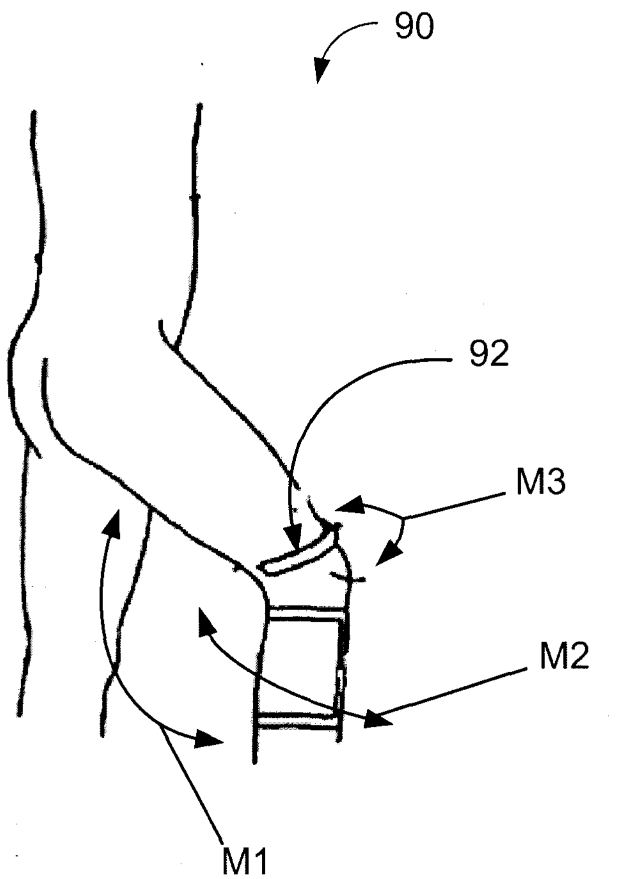

Fig. 1b

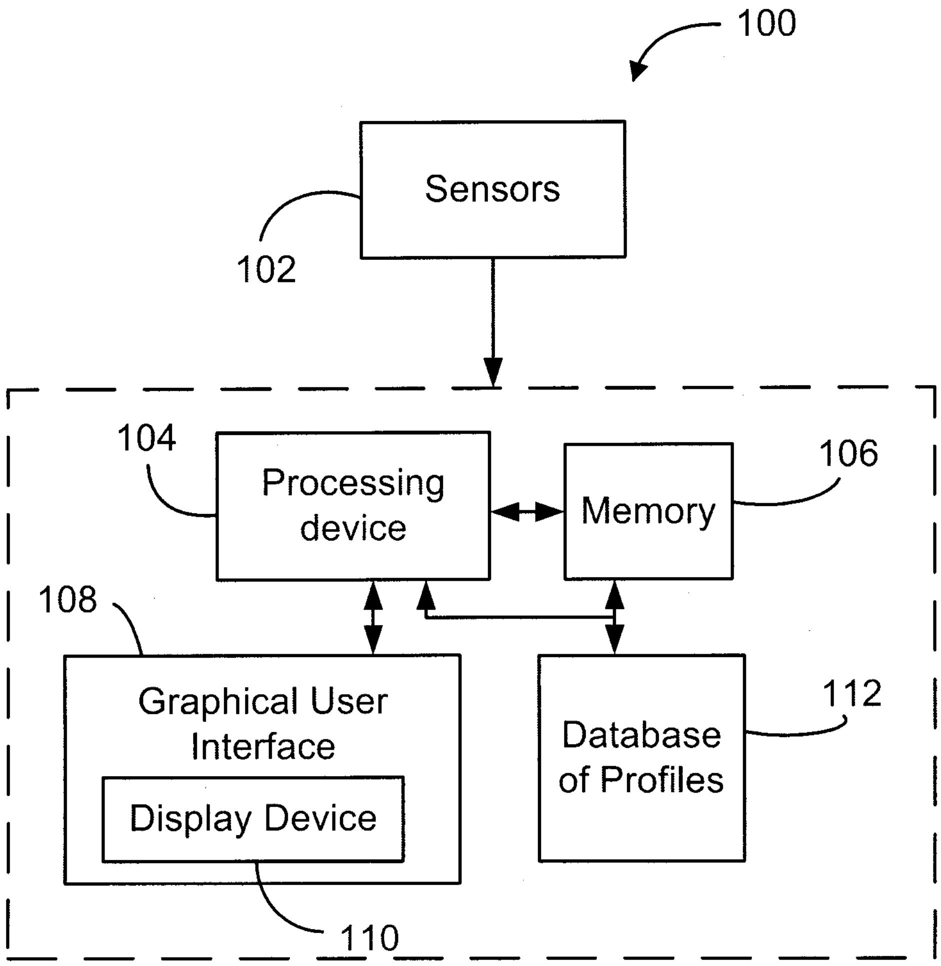
100
Sensors
102
104
Processing device
Memory
106
108
Graphical User Interface
Display Device
110
Database of Profiles
112

Fig. 2

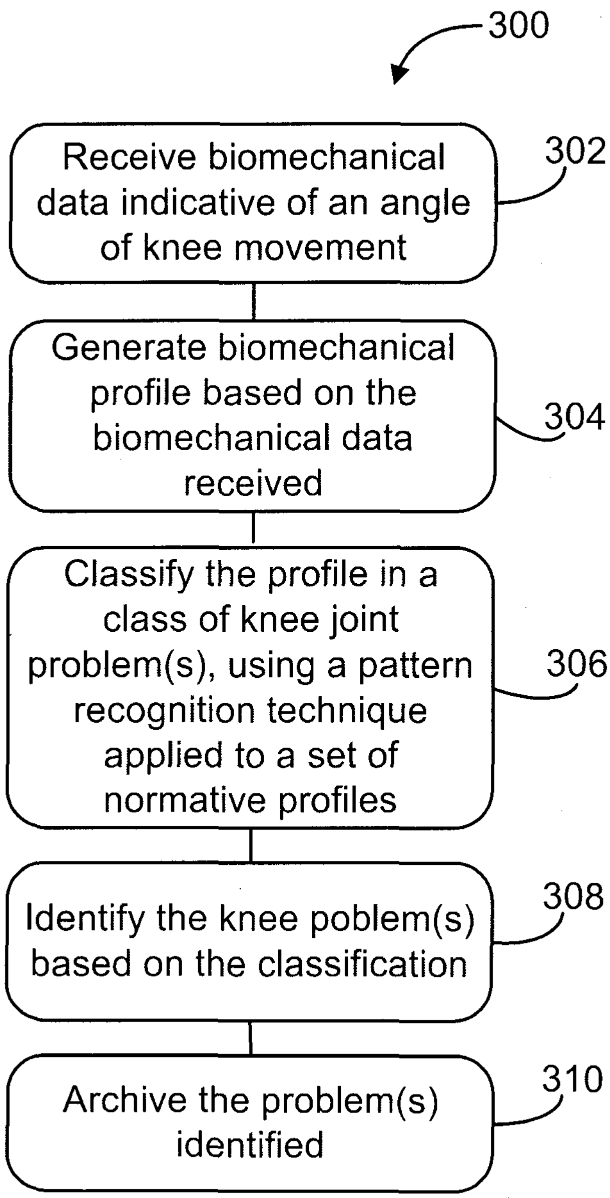
300
Receive biomechanical data indicative of an angle of knee movement
302
Generate biomechanical profile based on the biomechanical data received
304
Classify the profile in a class of knee joint problem(s), using a pattern recognition technique applied to a set of normative profiles
306
Identify the knee poblem(s) based on the classification
308
Archive the problem(s) identified
310

Fig. 3

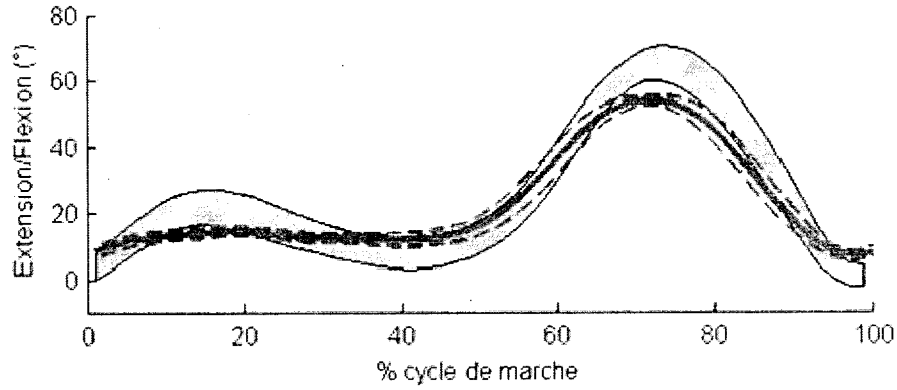

Fig. 4a

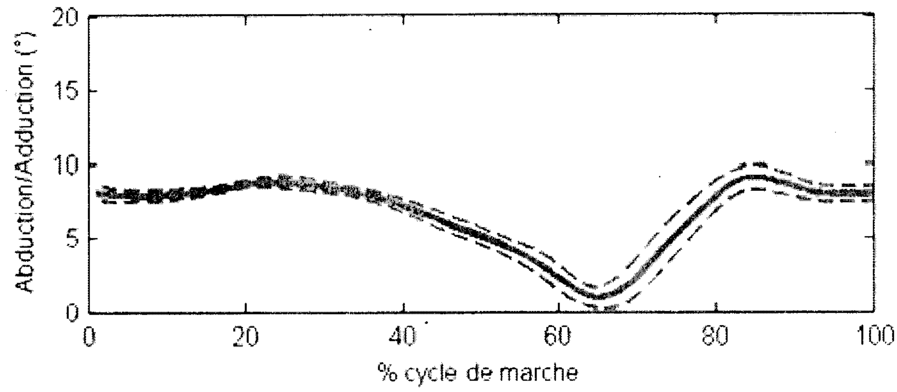

Fig. 4b

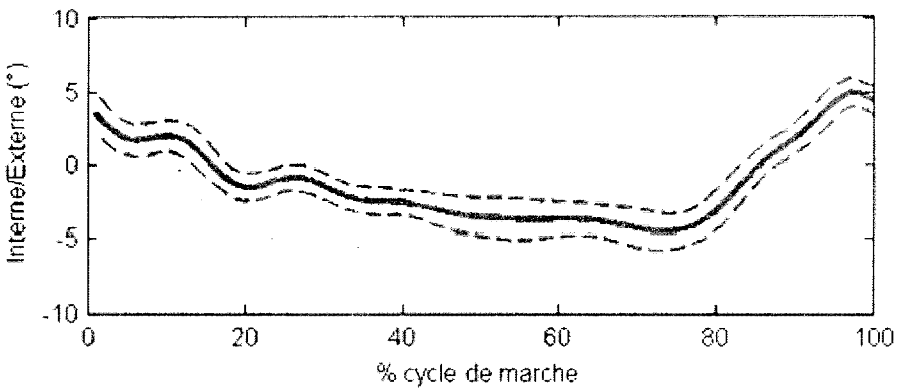

Fig. 4c

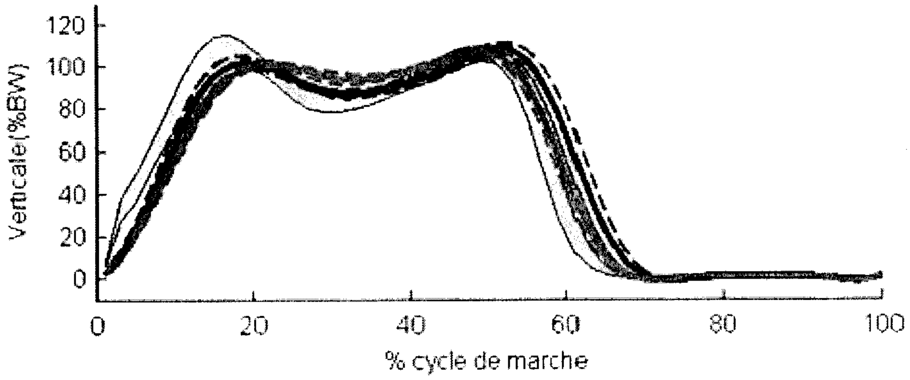

Fig. 5a

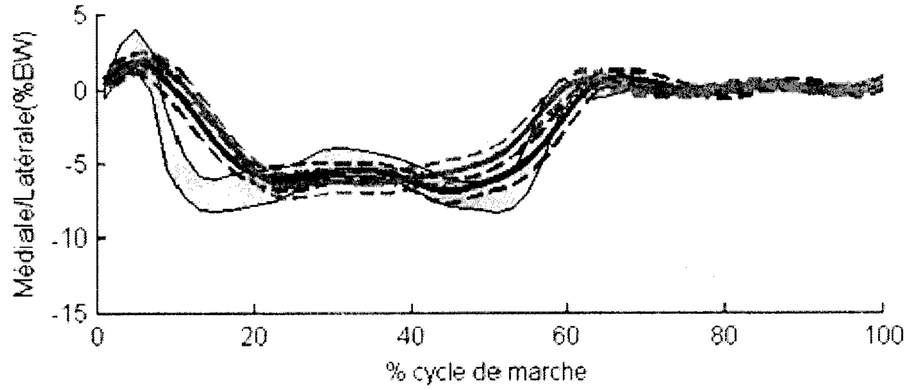

Fig. 5b

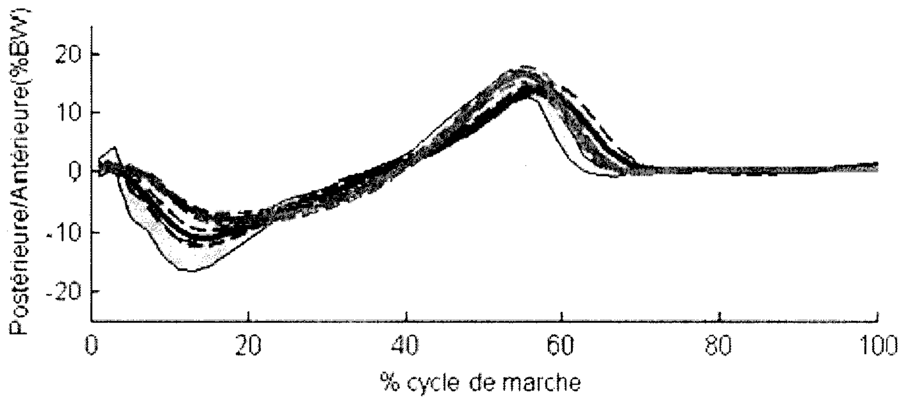

Fig. 5c

REFERENCES CITED IN THE DESCRIPTION

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patsnap

专利名称(译)	关节疾病诊断的评估和支持		
公开(公告)号	EP2566383B1	公开(公告)日	2020-03-18
申请号	EP2011777049	申请日	2011-05-03
[标]申请(专利权)人(译)	EMOVI有限公司		
申请(专利权)人(译)	EMOVI INC.		
当前申请(专利权)人(译)	EMOVI INC.		
[标]发明人	MEZGHANI NEILA DE GUISE JACQUES GRIMARD GUY BAILLARGEON DAVID OUAKRIM YOUSSEF PARENT GERALD FUENTES ALEXANDRE LAVIGNE PATRICK RANGER PIERRE		
发明人	MEZGHANI, NEILA DE GUISE, JACQUES GRIMARD, GUY BAILLARGEON, DAVID OUAKRIM, YOUSSEF PARENT, GÉRALD FUENTES, ALEXANDRE LAVIGNE, PATRICK RANGER, PIERRE		
IPC分类号	G16H50/20 A61B5/00 A61B5/103 A61B5/11		
CPC分类号	A61B5/1038 A61B5/112 A61B5/1122 A61B5/4528 A61B5/4585 A61B5/6828 A61B5/7264 A61B5/7267 A61B2560/045 A61B2562/0219 G16H50/20		
代理机构(译)	LAVOIX		
优先权	12/772701 2010-05-03 US		
其他公开文献	EP2566383A4 EP2566383A1		
外部链接	Espacenet		

摘要(译)

本文件描述了一种用于识别和表征膝关节问题的装置和方法。 根据一个实施例，该方法包括从传感器接收生物力学数据并基于该生物力学数据生成生物力学轮廓，该生物力学数据表示膝关节的运动。 该方法还涉及在处理设备中，通过将模式识别技术应用于与多个类别之一相关联的规范生物力学轮廓，将膝关节的生物力学轮廓分类为多个类别的膝关节问题之一。 与至少一个膝关节问题相对应的多个类别； 基于分类，将问题识别为包括多个类别之一的至少一个膝关节问题； 并将在存储设备中识别出的问题存档，以便在咨询期间可以访问该问题。

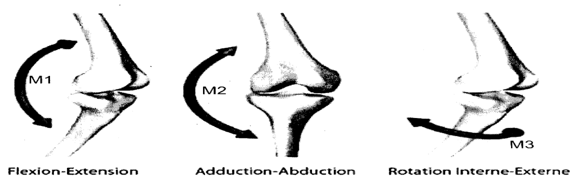

Fig. 1a (Prior Art)

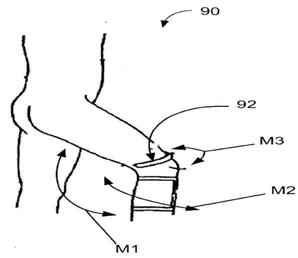

Fig. 1b