Title: EXERCISE MONITORING SYSTEM AND METHOD

Abstract: The present invention relates to an exercise monitoring system (3) utilising one or more inertial sensors (25). The present invention also relates to a method of monitoring the performance of a physical activity by an individual (5). The method involves locating one or more inertial sensors (25) on the individual (5) and collecting data from the inertial sensor(s) (25) while the individual performs the physical activity. The collected data is then processed to determine the movements of the individual (5).
For two-letter codes and other abbreviations, refer to the “Guidance Notes on Codes and Abbreviations” appearing at the beginning of each regular issue of the PCT Gazette.
EXERCISE MONITORING SYSTEM AND METHOD

The present invention relates to an exercise monitoring system and a method of monitoring the performance of an exercise.

An exercise bonus system is known from PCT/US03/15672 whereby a user carries a portable sensor and the user's movements are tracked by a series of stationary sensors. A stationary base station is provided to transmit stored data from the portable sensor to allow a bonus point system to be determined. This system requires a plurality of stationary sensors to be installed and is not intended to be used in a single location, such as a gymnasium. Equally, the system is only capable of monitoring the movements of the user and is, therefore, of limited use as a training tool.

It is known from PCT/US95/06626 to provide apparatus for measuring and visually displaying a user's body movements. Sensing means such as a potentiometer is coupled to the user's joints to measure the movements of the respective joints. The sensing means allows the movement of each joint to be measured directly, but this may be uncomfortable for the user. Moreover, it is time consuming to locate the sensing means properly over each joint to provide accurate measurements.

US 6,251,048 discloses an electronic exercise monitor comprising an exercise motion detector coupled to a processor to provide verbal instructions to the user. However, the motion detector is intended only to confirm that a particular motion has been performed, for example to count repetitions in an exercise set, and the monitor is not suitable for providing feedback on the technique.

An alternative approach is to utilise a camera to monitor the movements of an individual. Although an image corresponding to that recorded by the camera may be displayed, this technique cannot readily provide accurate feedback to the user. An example of this type of system is EyeToy® Kinetic for Playstation® 2.

There remains a need to provide an exercise monitoring system capable of accurately tracking the movements of a user. It has been recognised that a
higher degree of accuracy is required in the tracking of the user's movements to enable appropriate feedback to be given. It has also been appreciated that the tracking should be performed substantially in real-time to enable feedback to be provided to the user whilst they are performing the exercises.

Viewed from a first aspect, the present invention relates to an exercise monitoring system comprising at least one inertial sensor. At least in preferred embodiments, said at least one inertial sensor enables the movements of the individual using the system to be tracked to a high degree of accuracy, substantially in real-time. Thus, an individual using the system can be provided with feedback to assist them while they perform exercises.

The exercise monitoring system may comprise a single inertial sensor, for example to monitor the movement of the individual's torso. Preferably, however, a plurality of inertial sensors is provided. The system may comprise 3, 4, 5, 6, 7, 8 or more inertial sensors.

In use, one or more of the inertial sensors are preferably provided on a limb of an individual using the system. In use, one or more of said inertial sensors may be provided on the torso of an individual using the system.

In use, the inertial sensors are preferably arranged to form a chain. The position of each inertial sensor may be determined with reference to the position of the or each previous inertial sensor in said chain. The position of a first inertial sensor in the chain is preferably determined relative to a reference point. A tracking device may be provided for enabling the position of said reference point to be determined.

More than one chain of inertial sensors may be provided, for example to enable the movement of different limbs to be monitored. A tracking device is preferably associated with each chain of inertial sensors. A single tracking device may be associated with several chains of inertial sensors.

A cable or wire may be provided to allow data relating to the output of the at least one inertial sensor to be sent to a processor. Preferably, however, the exercise monitoring system comprises a transmitter for transmitting data relating to the output of said at least one inertial sensor to a remote receiver. In use, the transmitter is preferably located on the person of an individual using
the system. The transmitter may, for example, be provided in an arm band to be worn by the individual using the system or in a back-pack.

The exercise monitoring system is preferably provided with a dedicated receiver for receiving the signal transmitted by said transmitter. The dedicated receiver is preferably provided in a base station. The base station preferably remains stationary while in use and may be fixed in place.

A tracking device is preferably provided for determining a reference point for said at least one inertial sensor. The tracking device is preferably wireless. Although a visual tracking device may be provided, these typically have limited fields of vision.

The wireless tracking device is most preferably a Near-Field Electromagnetic Ranging (NFER) device. The exercise monitoring system is preferably provided with an NFER transmitter. In use, the NFER transmitter is preferably located on the person of an individual using the system. A plurality of NFER receivers is preferably provided. The NFER receivers may be provided inside a piece of exercise equipment forming part of the exercise monitoring system, but they are preferably located externally of any related exercise equipment. Further details of NFER tracking systems are disclosed in US 2004/0032363 (Schantz et al.) and the contents of this application are incorporated herein in their entirety by reference.

A processor is preferably provided for processing the data from said at least one inertial sensor to monitor the movements of an individual using the system. In use, the processor preferably provides the individual with feedback on their performance. A monitor may be provided for displaying visual feedback; and/or one or more speakers may be provided for giving audio feedback.

The processor may also display graphics, such as symbols, characters and/or pictures, on a monitor. In use, the graphics may respond to the exercise performed by the individual. The performance of a particular exercise may result in a particular response from the graphics displayed on screen, for example a particular animation or routine may be triggered. Thus, the user may interact with the on-screen display by performing certain physical activities.
The processor may compare the movements of the individual with a stored template. The stored template may, for example, contain data relating to the movements and/or accelerations associated with a particular physical activity when it is performed correctly. Thus, the exercise monitoring system can determine how well the physical activity is being performed. Prior art systems typically only ascertain that a particular motion has been performed, whereas the exercise monitoring system of the present invention can provide a qualitative assessment. This is an advantage the present invention provides over known systems. A database storing templates for a range of different physical activities is preferably provided.

The processor may also score the individual's performance of certain exercises. The score may, for example, be determined based on the result of a comparison of the individual's performance of a particular exercise or set of exercises with a stored set of data. As outlined above, the stored data may relate to an exercise performed by the individual before, or it may relate to a stored template of correct technique for a given exercise.

A data storage device, such as a hard disc, may be provided. If the system is installed in a gymnasium used by several people, an individual may be provided with a memory card containing personal data, for example data relating to previous exercises performed by the individual.

The or each inertial sensor is preferably capable of measuring acceleration in two directions. More preferably, the or each inertial sensor is capable of measuring acceleration in three directions. The or each inertial sensor may comprise one or more gyroscopes.

The processor is preferably suitable for monitoring the movements of the individual to determine a start position and/or an end position of a physical activity. The start position and/or the end position may, for example, be determined during a calibration sequence.

The physical activity may be cyclical requiring that several repetitions are performed. The processor may determine the start position and/or the end position of at least one of said cycles while the physical activity is performed. If a calibration sequence is also performed, the processor may compare the start
position and/or the end position determined during the calibration sequence to the respective position(s) whilst the physical activity is performed.

The exercise monitoring system may be suitable for monitoring exercises performed underwater. In use, the system may monitor the movements of an individual in a body of water, such as a swimming pool. The system is preferably provided in a frame mountable at a side of a swimming pool. The frame may be movably mounted to allow it to be raised and lowered relative to the swimming pool. For example, the frame may be pivotably mounted on the side of the swimming pool.

A tether may be provided for securing an individual in position relative to the system. It is envisaged that this may be suitable for physiotherapy. Preferably, the tether would provide support for the individual.

To enable the system to be employed underwater, the at least one inertial sensor may be waterproof or may be provided in a waterproof casing.

Viewed from a still further aspect, the present invention relates to a training system comprising at least one inertial sensor and a processor, wherein the processor compares data relating to the movements measured by said at least one inertial sensor to stored data. The stored data may, for example, relate to the movements and/or accelerations associated with a particular physical activity when it is performed correctly. The stored data may be generated during a calibration sequence. The calibration sequence may, for example, require an individual to perform one or more repetitions of a physical activity.

An individual using the system can be provided with automated feedback based on the results of the comparison. Thus, the system at least in preferred embodiments can provide a virtual trainer. The system could, for example, be used to assist with the training of a golf swing.

Viewed from a further aspect, the present invention relates to a method of monitoring an individual’s performance of a physical activity, the method comprising the steps of: (a) locating at least one inertial sensor on the individual; (b) collecting data from said at least one inertial sensor while the individual performs the physical activity; and (c) processing the data to
determine the movements of the individual. The physical activity is typically an exercise. At least in preferred embodiments, the method enables the individual's performance of the physical activity to be assessed qualitatively.

The method typically involves locating a plurality of inertial sensors on the individual. The inertial sensors are preferably each capable of measuring acceleration in three directions. The step of processing the data may be performed by a processor located on the person of the individual or by a processor located remotely, for example in a fixed base station.

The method may comprise the step of comparing the movements of the individual to a stored template. The stored template may, for example, contain data relating to the movements and/or accelerations associated with a particular physical activity when it is performed properly. Thus, the method according to the present invention can determine how well the physical activity is being performed. Prior art systems typically only ascertain that a particular motion has been performed, whereas the method according to the present invention allows a qualitative assessment. A database storing templates for a range of different physical activities is preferably provided.

The method may comprise the step of comparing the movements of the individual to the movements recorded previously for the same individual.

The individual may be provided with feedback. The feedback may, for example, provide technique tips or offer encouragement. The feedback may, for example, be based on the results of a comparison. To allow the individual to adjust their technique while they are performing the physical activity, the feedback is preferably provided substantially in real-time.

The feedback may be visual and/or audio. For example, the individual may be provided with on-screen prompts. Alternatively, synthesised or pre-recorded dialogue or audio comments may be output through one or more speakers. Alternatively, a series of beeps may sound and the frequency or tone of the beeps varied to provide feedback. For example, the frequency of the beeps may increase to advise the individual that the physical activity is being performed correctly.
The method may further comprise a calibration step. Preferably, the calibration step is performed before the individual performs the physical activity. The calibration step preferably determines a start position and/or an end position for the physical activity. The calibration step may allow for variations in the positioning of said at least one inertial sensor on the individual.

The physical activity may be cyclical requiring that several repetitions are performed. The method may include determine the start position and/or the end position of at least one of said cycles while the physical activity is performed. If a calibration sequence is also performed, the method may include a step of comparing the start position and/or the end position determined during the calibration sequence to the respective position(s) whilst the physical activity is performed. The method preferably also includes the step of displaying graphics on a screen whilst the individual performs the physical activity. The graphics preferably change in response to one or more of the physical activities performed by the individual. For example, a routine or animation may be performed in response to the completion of a particular physical activity.

The method may include the additional step of providing a score. The score may, for example, be dependent on the individual's technique as they perform a particular physical activity; the number of repetitions completed; or the time taken to complete one or more physical activities. To determine a score related to technique, a comparison may be made between the individual's movements and a stored template, as discussed herein.

A plurality of said inertial sensors may be provided. The inertial sensors are preferably arranged in a chain. The method preferably includes the step of determining the position of each inertial sensor in said chain with reference to the position of the or each preceding inertial sensor in said chain. The method may also comprise determining the position of a reference point for said chain of inertial sensors.

The physical activity may be performed in a gymnasium or it may be performed underwater, for example in a swimming pool. The method may comprise the further step of tethering the individual in position prior to said physical activity being performed.
Viewed from a still further aspect, the present invention relates to an exercise monitoring station comprising a receiver for receiving a signal providing data relating to movements measured by at least one inertial sensor. The exercise monitoring station may be provided with at least one NFER receiver for receiving an NFER signal. The exercise monitoring station is preferably incorporated into a piece of exercise equipment. The piece of exercise equipment may, for example, be a multi-gym.

Viewed from a yet still further aspect, the present invention relates to an exercise monitoring device comprising at least one inertial sensor. The exercise monitoring device preferably comprises a plurality of inertial sensors. The inertial sensors may be arranged in a chain. The exercise monitoring preferably comprises a transmitter for transmitting data relating to the output of said at least one inertial sensor. The transmitter may, for example, be an NFER transmitter. The device may be provided in an armband; on a pouch worn around the waste of the individual; or in a backpack.

Viewed from a further aspect, the present invention relates to a device for monitoring movement comprising an NFER transmitter and at least one inertial sensor. The device is preferably provided with a plurality of inertial sensors. In use, one or more of the inertial sensors may be provided on a limb or on the torso of an individual using the device. A transmitter is preferably provided for transmitting data relating to the output of said at least one inertial sensor. The device preferably comprises a plurality of inertial sensors. The inertial sensors may be arranged in a chain.

Viewed from a still further aspect, the present invention relates to a tracking device for monitoring movement, the tracking device comprising at least one transmitter and at least one inertial sensor. In use, said at least one transmitter transmits a signal which enables the relative position of the transmitter to be determined. The transmitter may thereby provide a reference point for said at least one inertial sensor when the device is operating.

The device is typically used to monitor the movement of an individual, for example as part of a motion capture system or exercise equipment. The transmitter is typically located on the person of the individual whose movements
are to be monitored. The transmitter may, for example, be located in a pocket or in a backpack.

To enable a range of movements to be monitored, the device preferably comprises a plurality of inertial sensors. In use, the inertial sensors may be provided on a limb of an individual using the device. For example, one or more of said inertial sensors may be provided on each side of an individual's joint. At least one inertial sensor may be provided on the torso, or on the head of the individual. Additional movements may be monitored by providing one or more inertial sensors on the digits of an individual. The inertial sensors may be arranged in a chain.

The device preferably comprises a data transfer device for sending data relating to the output of said at least one inertial sensor to a base station. The data transfer device may send the data over a physical connection, such as an umbilical cable. Alternatively, the data transfer device may send the data wirelessly, for example as a radio signal.

The transmitter preferably transmits a radio signal or sound waves. In use, the radio signal or sound waves may be detected by one or more receivers to enable the relative position of the transmitter to be determined.

In one embodiment, the at least one transmitter may be fixed in position and, in use, the transmitted signal is received by one or more movable receivers. Alternatively, the at least one transmitter may be movable and, in use, the transmitted signal is received by one or more fixed receivers.

The device may be used to play a game and/or perform an exercise, as described herein. At least in preferred embodiments, the device may track movements at least substantially in real-time.

Viewed from a still further aspect, the present invention relates to a tracking system comprising a device as described herein and one or more receivers for receiving a signal transmitted from the at least one transmitter associated with said device. Preferably a plurality of receivers are provided to allow the position of the at least one transmitter to be determined.

Viewed from a yet further aspect, the present invention relates to a method of tracking movement comprising the steps of:
transmitting a signal from at least one transmitter;
receiving the transmitted signal and determining the relative position of said at least one transmitter; and
monitoring the movement of at least one inertial sensor.

By determining the relative position of the transmitter a reference point can be determined for the at least one inertial sensor. Thus, an individual's movements may be tracked accurately for example as part of a motion capture system. The transmitter is typically worn by an individual, for example in a backpack.

The step of monitoring the movement of said at least one inertial sensor typically comprises sending data generated by said at least one inertial sensor to a base station. A data transfer device is preferably provided to send the data to the base station.

The signal transmitted by the transmitter is typically received by one or more receivers to enable the relative position of the transmitter to be determined.

The transmitter may transmit a radio signal or sound wave.

In certain applications it may be desirable to provide more than one transmitter, for example to provide more than one reference point.

In one embodiment, the at least one transmitter may be fixed in position and at least one movable receiver provided for receiving the transmitted signal. Alternatively, said at least one transmitter may be movable and at least one fixed receiver provided for receiving the transmitted signal.

The method may be used to track movement to provide a control mechanism for playing a game, such as an interactive video game. Alternatively, the method may be used to track movement whilst an exercise is performed.

Viewed from a still further aspect, the present invention relates to a method of monitoring an individual's performance of a physical activity, the method comprising the step of determining a start position and/or an end position for a cycle of said physical activity. The individual's start position and/or end position for said cycle may be compared with stored positional data.
The stored positional data may be a standard template or may be data
generated during a calibration sequence. A qualitative assessment of the
individual's performance may thereby be made.

The method may include providing a prompt to the individual to repeat
the exercise when the end position has been reached. Thus, the method may
help to ensure that the individual completes full cycles of the physical activity.

The method may comprise the additional steps of locating at least one
inertial sensor on the individual; and collecting data from said at least one
inertial sensor while the individual performs the physical activity.

Preferred embodiments of the apparatus and methods described herein
may determine the position of a reference point for the one or more inertial
sensors. At least in preferred embodiments, the position of the reference point
may be determined in at least two dimensions and, more preferably, in three
dimensions.

A preferred embodiment of the present invention will now be described,
by way of example only, with reference to the accompanying drawings, in
which:

Figure 1 shows exercise equipment incorporating an exercise monitoring
system in accordance with the present invention; and

Figure 2 shows schematically the operation of the exercise monitoring
system in accordance with the present invention.

Exercise equipment 1 incorporating an exercise monitoring system 3 in
accordance with the present invention will now be described with reference to
Figures 1 and 2.

The exercise equipment 1 comprises a plurality of different pieces of
exercise apparatus to enable an individual 5 to perform different types of
exercise. The present embodiment comprises first, second, third and fourth
flexible bands 7, 9, 11, 13 of different elasticity and resistance for performing
exercises, such as sit-ups and resistance training exercises. A pivoting and/or
rotatable platform 15 is provided for further exercises. A seat 17 is provided for
the individual 5 using the exercise equipment 1. Foot locks 19 are also
provided for performing sit-ups and the like.
The exercise monitoring system 3 comprises a processor 19, such as a personal computer, housed in a dedicated base station 21. A monitor 23 and a pair of loud speakers 24 provide the individual 5 with feedback on their performance. The types of feedback provided by the exercise monitoring system 3 will be described in greater detail below. The base station 21 is typically provided with a keyboard and/or mouse to allow desired parameters to be input, for example to select a particular work-out routine. Alternative input methods, such as a remote control or voice recognition, may be implemented.

To monitor exercises, a plurality of inertial sensors 25 is provided on the individual 5. The inertial sensors 25 typically each comprise accelerometers for measuring acceleration in one, two or three directions. In the present embodiment a total of five inertial sensors 25 are provided on the individual 5. First and second inertial sensors 25a, 25b are provided on the forearm and upper arm respectively of the left arm of the individual 5. Third and fourth inertial sensors 25c, 25d are provided on the forearm and upper arm respectively of the right arm of the individual 5. A fifth sensor 25e is provided on the back of the individual 5. It will be appreciated that less than or more than five inertial sensors 25 may be used to provide different levels of accuracy.

The first and second inertial sensors 25a, 25b form a first chain; and the third and fourth sensors 25c, 25d form a second chain.

The inertial sensors 25 could be provided in a vest to be worn by the individual 5. Preferably, however, the inertial sensors 25 are each secured in place by straps, for example using Velcro. The inertial sensor 25e to be located on the back of the individual 5 is provided in a back-pack 27.

The inertial sensors 25 are connected to a processor and transmitter 29 located in the back-pack 27 worn by the individual 25. The transmitter 29 transmits a signal to a receiver 31 housed in the base station 21 to convey data measured by the inertial sensors 25 to the processor 19. Dedicated transmitters may be provided for the data and NFER transmissions.

The transmitter 29 also transmits a Near-Field Electromagnetic Ranging (NFER) signal. Three NFER receivers 33a, 33b, 33c are provided to receive the NFER signal and enable the position of the transmitter 29 to be accurately
determined by an NFER processor 35. The receivers 33a, 33b, 33c may be
provided inside the exercise equipment 1 but are preferably provided externally
of the exercise equipment 1.

Tracking the position of the transmitter 29 provides a reference point for
the inertial sensors 25 and enables the orientation of the left and right arms of
the individual 5 to be determined. In alternative embodiments, a second,
separate transmitter may be provided to transmit the NFER signal in addition to
the transmitter 29 for transmitting a signal to the receiver 31.

The operation of the exercise equipment 1 will now will be described with
reference to Figure 2.

The inertial sensors 25 are attached to the individual 5 as described
above and the transmitter 31 activated. The NFER signal transmitted by the
transmitter 31 is detected by the NFER receivers 33a, 33b, 33c. The NFER
processor 35 determines the location of the transmitter 31 and this data is
supplied to the processor 19; this provides a reference point for the inertial
sensors 25.

The inertial sensors 25 measure the acceleration of the arms and back of
the individual 5. The measured data is transmitted to the receiver 31 by the
transmitter 29. The measured data is supplied to the processor 35 and the
relative position and orientation of each inertial sensor 25 calculated.
Accordingly, the position and orientation of the arms and back of the individual 5
may be accurately modelled.

The individual 5 performs exercises, such as sit-ups or resistance
training, on the exercise equipment 1. The motion of the individual's arms and
back are calculated by the processor 19 during the exercises in real-time. The
generated data can be stored, for example on a removable storage disc or card,
for future reference. A graphical representation of the movements can be
displayed on the monitor 23 to help the individual 5 visualise the exercise.

A comparison may be made between the measured movements of the
individual 5 and movements recorded previously for the same exercise. Again,
this comparison can be performed in real-time. Feedback can be given to the
individual 5 based on the results of this comparison, for example regarding technique or endurance.

Alternatively, a comparison may be made between the measured movements of the individual 5 and stored model movements for correct technique. Again, this comparison can be performed in real-time. Feedback can again be given to the individual 5 based on the results of this comparison, for example to highlight areas where their technique is not ideal.

It will be appreciated, therefore, that the feedback provided by the exercise monitoring system 3 can act as a virtual trainer for the individual 5. The feedback can be provided on the monitor 23 and/or via the loud speakers 24, for example using pre-recorded dialogue. Not only can the feedback take the form of encouragement, but it can also offer tips on technique and highlight areas where the individual 5 should focus.

The processor 19 may also set tasks for the individual 5 while they perform exercises. For example, visual prompts or cues may be displayed on the monitor 23 to which the individual 5 must respond. Since the movements of the individual 5 are monitored, the individual 5 may interact with these visual prompts or cues by performing particular movements or exercises. It is envisaged that these interactive games could be particularly effective at encouraging the individual 5. Additional content could be downloaded to the base station 21 to extend the like of the exercise equipment 1.

Prior to performing an exercise, the user 5 may have to calibrate the exercise equipment 1. This may be achieved by performing a calibration sequence in which the user performs the exercise, for example in response to visual prompts on the screen 23. The visual prompts may take the form of one or more images; or a video showing the correct technique for performing the exercise. The user may perform the exercise once during the calibration sequence, for example a single biceps curl or leg press may be performed.

The calibration sequence enables the processor 19 to determine a start position and an end position for the individual 5 on that particular exercise. Subsequently, the individual 5 may perform the exercise and the processor 19 may compare each cycle of the exercise with the data generated during the
calibration sequence. This comparison may enable a qualitative analysis of the individual's technique.

Furthermore, the individual 5 may be provided with prompts to repeat an exercise only when the appropriate end position has been reached. The exercise monitoring system 3 may ensure that the individual starts and finishes each exercise in the correct position. Thus, exercise monitoring system 3 encourages or requires that the individual 5 performs complete cycles of the exercise. An example of a possible prompt would be to require that the individual 5 returns to the start position in order to reload a weapon as part of an onscreen game.

The calibration sequence may improve the accuracy of the exercise monitoring system 3 since variations in the positioning of the inertial sensors 25 on the individual 5 may be accommodated. For example, if the strap securing the second inertial sensor 25a in position is twisted, the calibration sequence will enable the exercise monitoring system 3 to allow for the resulting change in position and/or orientation when the individual 5 uses the exercise equipment 1.

In addition to measuring the movements of the individual 5, sensors may be provided to monitor the movement and/or acceleration of pieces of apparatus provided in the exercise equipment 1. For example, the pivoting and/or rotation of the platform 15 may be measured directly. This additional data may be combined with the movement data for the individual 5 to provide further information relating to their activities.

It is envisaged that the exercise equipment 1 would primarily be used in gymnasiums but it may also be used in private homes. Furthermore, it is envisaged that the exercise equipment 1 would also be applicable for physiotherapy treatment and, therefore, could be used in hospitals and physiotherapy centres.

If will be appreciated that it is not essential that NFER techniques are employed to provide a reference point for the inertial sensors 5. Other forms of wireless tracking, such as a camera and suitable software, are suitable. Equally, physical tracking techniques may be employed.
Furthermore, rather than use a wireless transmitter to transmit the data from the inertia! sensors, the sensors may be connected directly to the base station by a flexible wire or cable.

The present invention has been described with reference to a single piece of exercise equipment 1 offering a range of different exercise options. However, the exercise monitoring system 3 has broader applications. For example, it is envisaged that the exercise monitoring system 3 could monitor an individual's use of different pieces of equipment, such as separate exercise stations. Equally, the exercise monitoring system 3 could monitor the use of free weights, such as barbells and dumbbells, for different exercises. In these arrangements, a base station comprising a processor 19 may be provided in the desired exercise area. The processor 19 may determine the movements of one or more individuals and provide output to one or more monitors 23.

Furthermore, the exercise monitoring system 3 could be used to monitor movements performed in a swimming pool or the like. The exercise monitoring system 3 could be provided at the side of the swimming pool to monitor the position and/or orientation of waterproof inertia! sensors 25 worn by the individual 5. The exercise monitoring system 3 could be provided in a pivotably mounted housing or frame which can be pivoted into position at the edge of the pool. A tether or line may be provided to keep the individual 5 in the desired location proximal the exercise monitoring system 3. The tether or line may be provided with a catch, such as a hook or clip, to be attached to a harness worn by the individual 5. This exercise monitoring system 3 could be used in physiotherapy.

The skilled person will understand that various changes and modifications may be made to the exercise monitoring system described herein without departing from the scope or spirit of the present invention.
Claims:

1. An exercise monitoring system comprising at least one inertial sensor.

2. An exercise monitoring system as claimed in claim 1 comprising a plurality of said inertial sensors.

3. An exercise monitoring system as claimed in claim 2, wherein, in use, one or more of said inertial sensors are provided on a limb of an individual using the system.

4. An exercise monitoring system as claimed in claim 2 or claim 3, wherein, in use, one or more of said inertial sensors are provided on the torso of an individual using the system.

5. An exercise monitoring system as claimed in any one of claims 2, 3 or 4, wherein, in use, said inertial sensors are arranged to form a chain.

6. An exercise monitoring system as claimed in any one of the preceding claims further comprising a transmitter for transmitting data relating to the output of said at least one inertial sensor.

7. An exercise monitoring system as claimed in claim 6, wherein, in use, the transmitter is located on the person of an individual using the system.

8. An exercise monitoring system as claimed in claim 6 or claim 7 further comprising a receiver for receiving the signal transmitted by said transmitter.

9. An exercise monitoring system as claimed in any one of the preceding claims further comprising a tracking device for determining a reference point for said at least one inertial sensor.
10. An exercise monitoring system as claimed in claim 9, wherein said tracking device is wireless.

11. An exercise monitoring system as claimed in claim 10, wherein the wireless tracker is a Near-Field Electromagnetic Ranging (NFER) device.

12. An exercise monitoring system as claimed in claim 11 further comprising an NFER transmitter.

13. An exercise monitoring system as claimed in claim 12, wherein, in use, said NFER transmitter is located on the person of an individual using the system.

14. An exercise monitoring system as claimed in claim 11, 12 or 13 further comprising a plurality of NFER receivers.

15. An exercise monitoring system as claimed in any one of the preceding claims, further comprising a processor for processing the data from said at least one inertial sensor to monitor the movements of an individual using the system.

16. An exercise monitoring system as claimed in claim 15, wherein, in use, said processor provides the individual with feedback.

17. An exercise monitoring system as claimed in claim 15 or claim 16, wherein said processor is suitable for monitoring the movements of said individual to determine a start position and/or an end position of a physical activity.

18. An exercise monitoring system as claimed in any one of the preceding claims, wherein the system is suitable for monitoring exercises performed underwater.
19. An exercise monitoring system as claimed in claim 18, wherein the system is provided in a frame mountable at a side of a swimming pool.

20. An exercise monitoring system as claimed in claim 18 or claim 19 further comprising a tether.

21. An exercise monitoring system as claimed in any one of the preceding claims, wherein said at least one inertial sensor is provided in a waterproof casing.

22. A training system comprising at least one inertial sensor and a processor, wherein the processor compares data relating to the movements measured by said at least one inertial sensor to stored data.

23. A training system as claimed in claim 22, wherein, in use, said stored data is generated during a calibration sequence.

24. A method of monitoring an individual's performance of a physical activity, the method comprising the steps of:
   (a) locating at least one inertial sensor on the individual;
   (b) collecting data from said at least one inertial sensor while the individual performs the physical activity; and
   (c) processing the data to determine the movements of the individual.

25. A method as claimed in claim 24 further comprising the step of comparing the movements of the individual to a stored template.

26. A method as claimed in claim 24 further comprising the step of comparing the movements of the individual to the movements recorded previously for the same individual.
27. A method as claimed in claim 25 or claim 26 further comprising the step of providing the individual with feedback based on the results of the comparison step.

28. A method as claimed in claim 27, wherein said feedback is provided substantially in real-time.

29. A method as claimed in claim 27 or claim 28, wherein said feedback is visual and/or audio.

30. A method as claimed in any one of claims 24 to 29 further comprising a calibration step.

31. A method as claimed in claim 30, wherein the calibration step is performed before the individual performs the physical activity.

32. A method as claimed in claim 30 or claim 31, wherein said calibration step determines a start position and/or an end position of the physical activity.

33. A method as claimed in claim 32, wherein said step of processing the data includes determining when the individual is at a start position and/or at an end position of the physical activity.

34. A method as claimed in any one of claims 24 to 33 further comprising the step of displaying graphics on a screen whilst the individual performs the physical activity.

35. A method as claimed in claim 34, wherein the graphics change in response to the physical activity performed by the individual.
36. A method as claimed in any one of claims 24 to 35 further comprising the step of providing the individual with a score for the performance of the physical activity.

37. A method as claimed in any one of claims 24 to 36, wherein a plurality of said inertial sensors are arranged in a chain.

38. A method as claimed in claim 37, wherein the position of each inertial sensor in said chain is determined with reference to the position of the or each preceding inertial sensor in said chain.

39. A method as claimed in claim 38, comprising the step of determining the position of a reference point for said chain of inertial sensors.

40. A method as claimed in any one of claims 24 to 39, wherein the physical activity is performed underwater.

41. A method as claimed in claim 40 further comprising the step of tethering said individual in position prior to said physical activity being performed.

42. An exercise monitoring station comprising a receiver for receiving a signal providing data relating to movements measured by at least one inertial sensor.

43. An exercise monitoring station as claimed in claim 42 further comprising at least one NFER receiver for receiving an NFER signal.

44. An exercise monitoring station as claimed in claim 42 or claim 43, wherein the station is incorporated into a piece of exercise equipment.

45. An exercise monitoring device comprising at least one inertial sensor.
46. An exercise monitoring device as claimed in claim 45 further comprising a transmitter for transmitting data relating to the output of said at least one inertial sensor.

47. An exercise monitoring device as claimed in claim 45 or claim 46 further comprising an NFER transmitter.

48. An exercise monitoring device as claimed in any one of claims 45 to 47, wherein the device is provided in a backpack.

49. A device for monitoring movement comprising an NFER transmitter and at least one inertial sensor.

50. A device as claimed in claim 49 comprising a plurality of said inertial sensors.

51. A device as claimed in claim 50, wherein, in use, one or more of said inertial sensors are provided on a limb of an individual using the device.

52. A device as claimed in claim 51, wherein, in use, one or more of said inertial sensors are provided on each side of a joint on the limb of an individual.

53. A device as claimed in any one of claims 50, 51 or 52, wherein said inertial sensors are arranged in a chain.

54. A device as claimed in any one of claims 50 to 53, wherein, in use, one or more of said inertial sensors are provided on the torso of an individual using the device.
55. A device as claimed in any one of claims 49 to 54 further comprising a transmitter for transmitting data relating to the output of said at least one inertial sensor.

56. A tracking device for monitoring movement, the tracking device comprising at least one transmitter and at least one inertial sensor.

57. A device as claimed in claim 56 comprising a plurality of said inertial sensors.

58. A device as claimed in claim 57, wherein, in use, one or more of said inertial sensors are provided on a limb of an individual using the device.

59. A device as claimed in claim 58, wherein, in use, one or more of said inertial sensors are provided on each side of a joint on the limb of an individual.

60. A device as claimed in any one of claims 57, 58 or 59, wherein said inertial sensors are arranged in a chain.

61. A device as claimed in any one of claims 57 to 60, wherein, in use, one or more of said inertial sensors are provided on the torso of an individual using the device.

62. A device as claimed in any one of claims 56 to 61 further comprising a data transmitter for transmitting data relating to the output of said at least one inertial sensor.

63. A device as claimed in any one of claims 56 to 62, wherein said at least one transmitter is suitable for transmitting a radio signal.
64. A device as claimed in any one of claims 56 to 62, wherein said at least one transmitter is suitable for transmitting an acoustic signal.

65. A tracking system comprising a device as claimed in any one of claims 49 to 64 and one or more receivers for receiving a signal transmitted from said at least one transmitter associated with said device.

66. A tracking system as claimed in claim 65, wherein, in use, said at least one transmitter is/are fixed in position.

67. A tracking system as claimed in claim 65, wherein, in use, said one or more receivers is/are fixed in position.

68. A method of tracking movement comprising the steps of:
   a) transmitting a signal from at least one transmitter;
   b) receiving the transmitted signal and determining the relative position of said at least one transmitter; and
   c) monitoring the movement of at least one inertial sensor.

69. A method as claimed in claim 68, wherein the step of monitoring the movement of said at least one inertial sensor comprises sending data generated by said at least one inertial sensor to a base station.

70. A method as claimed in claim 68 or claim 69, wherein said at least one transmitter transmits a radio signal.

71. A method as claimed in claim 68 or claim 69, wherein said at least one transmitter transmits an acoustic signal.

72. A method as claimed in any one of claims 68 to 71, wherein said at least one transmitter is fixed in position.
73. A method as claimed in any one of claims 68 to 72, wherein at least one receiver is provided for receiving the signal transmitted from said at least one transmitter.

74. A method as claimed in claim 73, wherein said at least one receiver is movable.

75. A method of monitoring an individual's performance of a physical activity, the method comprising the step of determining a start position and/or an end position for a cycle of said physical activity.

76. A method as claimed in claim 75 further comprising the steps of locating at least one inertial sensor on the individual; and collecting data from said at least one inertial sensor while the individual performs the physical activity.

77. An exercise monitoring system substantially as herein described with reference to the accompanying figures.

78. A method of monitoring an individual's performance of a physical activity substantially as herein described with reference to the accompanying figures.
**INTERNATIONAL SEARCH REPORT**

PCT/GB2007/001565

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. A63B24/00 A63B21/055

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

A63B G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td>NO 2004/049944 A (NEAL ROBERT J [AU]) 17 June 2004 (2004-06-17) page 1, line 4 - line 7 page 2, line 21 - page 3, line 21 page 4, line 18 - page 6, line 5 page 10, line 28 - line 29; figures</td>
<td>1-76</td>
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Further documents are listed in the continuation of Box C

See patent family annex

**Date of the actual completion of the international search** 16 August 2007

**Date of mailing of the International search report** 23/08/2007

Name and mailing address of the ISA/
European Patent Office, P B 5818 Palenlaan 2 NL-2280 HV Rijswik Tel (+31-70) 340-2040 Tx 31 651 epo nl Fax (+31-70) 340-3016

Authorized officer Michel s, Norbert
**DOCUMENTS CONSIDERED TO BE RELEVANT**

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<tr>
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### Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [ ] **Claim Nos 77, 78**
   - because they relate to subject matter not required to be searched by this Authority, namely
   - Claims 77 and 78 are defined by reference to the accompanying figures of the present application. According to PCT Article 6 and PCT Rule 6.2(b) claims should not contain such references except where absolutely necessary, what is not the case here. Consequently, claims 77 and 78 have not been searched.

2. [ ] **Claim Nos**
   - because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically

3. [ ] **Claim Nos**
   - because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

### Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims, it is covered by claims Nos.

### Remark on Protest

- [ ] The additional search fees were accompanied by the applicant's protest
- [ ] No protest accompanied the payment of additional search fees

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Form PCT/ISA/210 (continuation of first sheet (2)) (January 2004)
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