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(54) **Title:** CLASSIFYING MULTIPLE ACTIVITY EVENTS

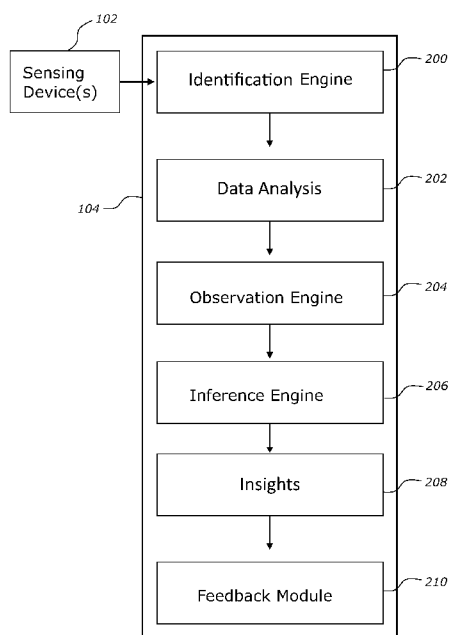


FIGURE 2

(57) **Abstract:** The invention relates to a method of classifying a plurality of activities associated to a user. The method comprises receiving first activity data indicative of a first activity performed by the user during a first time interval, the first activity data comprising a plurality of measurements associated to at least one first parameter monitored during the first activity; receiving second activity data indicative of a second activity performed by the user during a second time interval, the second activity data comprising a plurality of measurements associated to at least one second parameter monitored during the second activity, the second activity different to the first activity; a processor comparing at least some of the first activity data and at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium; a processor generating a set of observation alerts based at least partly on the comparison of the first activity data and the second activity data with the respective sets of measurements; a processor comparing the set of observation alerts with respective sets of observation alerts stored on a tangible computer readable medium; and on detecting a match between the set of observation alerts and at least one set of the stored observation alerts, a processor generating at least one inference alert. The invention also relates to similar systems and computer-executable instructions.

CLASSIFYING MULTIPLE ACTIVITY EVENTS

FIELD OF INVENTION

The invention relates to exercise and/or activity monitoring and in particular to virtual
5 guidance, coaching or alerts provided to a user based on patterns found in data from a
device or devices containing multiple sensors measuring data at different times.

BACKGROUND

Devices for monitoring physiological information such as heart rate, and other exercise
10 related information such as steps measured through an accelerometer or speed, distance
and heart rate exist. Such devices provide a means of representing the quality or
quantity of the exercise or activity conducted by a user wearing the device or exercising
on a machine incorporating the device. These representations come in the form of data.
The numbers may include values such as calories, steps taken, heart rates, speeds and
15 other detailed data.

The state of the art has reached a point where many sensors can be placed in a small
wearable device that is able to measure and gather large amounts of user activity data.
However, interpreting all the data can present a challenge to the user.

20 Devices generally known as 'talking devices' have evolved that provide artificially
generated speech. These devices provide information on an activity event that occurs
during the user's activity. For example, the device may monitor heart rate and
automatically suggest that the user slow down to get back into the green heart rate
25 training zone. Alternatively, the device is configured to suggest the user lift their stride
rate to an optimal pre-set zone.

These systems typically use a single monitored parameter so there is no context to the
alerts that they provide. This limits the accuracy of the alerts and information provided
30 as diagnosis is constrained to discussing the single parameter measured regardless of the
effect other parameters may have on the situation. Employing a smart inference engine
to provide alerts based on a single parameter is problematic without further parameters
to create context.

35 As virtual coaching and guidance evolve there is more than one way to solve the problem
of device intelligence. The systems can potentially use machine learning to draw
inferences for random patterns that occur. A domain expert or experts can employ a
rules based engine with pre-set patterns that the inference engine searches for and
responds to.

Many machine learning systems have been employed in an attempt to solve device intelligence but so far these have had limited results.

- 5 United States patent 5,769,793 titled 'System to Determine a Relative Amount of Patternness' to Pincus disclosed a method for determining patterns in a sequence of data and assigning a classification to the data, together with a comparator for comparing elements of a defined class to define a quantitative value of the regularity and stability of patterns of the elements to compute the approximate entropy value of the quantitative
10 amounts. Pincus does not teach comparing disparate data from different activities and different times. Nor does Pincus teach use of multiple observation alerts to generate an inference alert to a user.

- United States patent application publication 2007/0219059 titled 'Method and System for
15 Continuous Monitoring and Training of Exercise' to Schwartz discloses a system configured to capture vital signs from a plurality of sensors and performing pattern recognition to derive characteristic parameters and patterns with their values, including real time actual physical activity levels, and an expert coaching system that makes recommendations to improve training results based on exercise rules, expert training guidelines, athlete
20 training experiences, the activity levels and the extracted patterns. Schwartz does not teach classifications and alerts based on multiple different classified activities and activity events occurring at different times. Nor does Schwarz teach use of multiple observation alerts to generate an inference alert to a user.

- 25 United States patent 7,487,148 titled 'System and Method for Analysing Data' to Eaton Corporation/James discloses a data subsystem having a plurality of data types and analysis points, together with a pattern subsystem including a plurality of events, template data points and a pattern array and a correlation process for identifying a marker location. The search subsystem places markers on the data analysis points
30 indicative of the events without human intervention. James does not disclose comparing data from different activity classifications and events at different times. Furthermore, use of multiple observation alerts to generate an inference alert to a user is not disclosed.

- Another problem is that data and valuable information is currently present across
35 multiple data collecting systems which are siloed from each other. Each data set has potential value if it can be combined with other data sets. A runner's performance may have dropped based on their running data measured by their sports monitoring device. This effect may be due to long work hours and poor sleep quality. Prior art sports devices

do not measure these activities. Accurate inferences require a wide contextualisation of the data.

Furthermore, prior art observation alerts are based on limited context. Current advice systems are single observation alert based. This means that an incident happens for a single parameter that is being measured, where a single observation is made by the system and a comment or alert is automatically elicited. Multi-activity inferences cannot be made with no context.

It is an object of preferred embodiments of the present invention to address some of the aforementioned disadvantages. An additional or alternative object is to at least provide the public with a useful choice.

SUMMARY OF THE INVENTION

In one aspect the invention comprises a method of classifying a plurality of activities associated to a user, the method comprising: receiving first activity data indicative of a first activity performed by the user during a first time interval, the first activity data comprising a plurality of measurements associated to at least one first parameter monitored during the first activity; receiving second activity data indicative of a second activity performed by the user during a second time interval, the second activity data comprising a plurality of measurements associated to at least one second parameter monitored during the second activity, the second activity different to the first activity; a processor comparing at least some of the first activity data and at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium; a processor generating a set of observation alerts based at least partly on the comparison of the first activity data and the second activity data with the respective sets of measurements; a processor comparing the set of observation alerts with respective sets of observation alerts stored on a tangible computer readable medium; and on detecting a match between the set of observation alerts and at least one set of the stored observation alerts, a processor generating at least one inference alert.

The term 'comprising' as used in this specification means 'consisting at least in part of'. When interpreting each statement in this specification that includes the term 'comprising', features other than that or those prefaced by the term may also be present. Related terms such as 'comprise' and 'comprises' are to be interpreted in the same manner.

Preferably observation alerts are based on comparisons of measured parameters against thresholds.

5 Preferably observation alerts are generated when one or both of the first activity data and the second activity data exceeds a threshold, is less than a threshold, or lies within a range.

Preferably inference alerts are based on comparisons of a set of observation alerts with a plurality of stored sets of observation alerts.

10

Preferably different activity comprises different muscle activity.

Preferably different activity comprises different postural behaviour.

15 Preferably the first activity and/or the second activity is selected from sleep/bedtime, biomedical, work, CV, gym, behaviour, performance, environmental and neurocardio.

Preferably sleep/bedtime activity is measured by at least one parameter selected from sleep duration, deep sleep, rem sleep, light sleep, bed time, wake time, time, date.

20

Preferably biomedical activity is measured by at least one parameter selected from Electrocardiograph data, Blood Pressure, time, date.

25 Preferably work activity is measured by at least one parameter selected from steps, posture, active motion, inactivity, time, date, calendar, and appointments.

Preferably CV activity is measured by at least one parameter selected from activity type data, activity type compliance, speed compliance, easy compliance, resistance compliance, time and date.

30

Preferably gym activity is measured by at least one parameter selected from activity type data, activity type compliance, per exercise = rep compliance, rep speed compliance, rest compliance, weight compliance, time, date.

35 Preferably behaviour activity is measured by at least one parameter selected from off season, number of workouts completed vs time, workout pattern, big weeks, taper weeks, race week, pace, SR, leave home time, work arrival time, leave for home time, arrive home time, time, date.

Preferably performance activity is measured by at least one parameter selected from cardio performance, muscular performance, overall performance, time, date.

5 Preferably environmental activity is measured by at least one parameter selected from temperature, weather forecast, humidity, altitude, terrain.

Preferably neurocardio activity is measured by at least one parameter selected from posture, respiration, inactive time, heart rate variability, time, date.

10 Preferably the first activity data comprises a plurality of measurements associated to a first set of parameters monitored during the first activity.

Preferably the second activity data comprises a plurality of measurements associated to a second set of parameters monitored during the second activity.

15 Preferably comparing the at least some of the first activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the at least some of the first activity data with measurements associated to the at least one parameter monitored during the first activity.

20 Preferably comparing the at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the at least some of the second activity data with measurements associated to the at least one parameter monitored during the second activity.

25 Preferably the second time interval can be different to the first time interval or can be overlapping.

30 In another aspect the invention comprises a system configured to classify a plurality of activities associated to a user, the system comprising at least one computer-readable medium; and at least one processor, the at least one processor programmed to: receive first activity data indicative of a first activity performed by the user during a first time interval, the first activity data comprising a plurality of measurements associated to at least one first parameter monitored during the first activity; receive second activity data
35 indicative of a second activity performed by the user during a second time interval, the second activity data comprising a plurality of measurements associated to at least one second parameter monitored during the second activity, the second activity different to the first activity; compare at least some of the first activity data and at least some of the second activity data with respective sets of measurements stored on a tangible computer

readable medium; generate a set of observation alerts based at least partly on the comparison of the first activity data and the second activity data with the respective sets of measurements; compare the set of observation alerts with respective sets of observation alerts stored on the at least one computer-readable medium; and on
5 detecting a match between the set of observation alerts and at least one set of the stored observation alerts, generate at least one inference alert.

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- 10 Preferably performance activity is measured by at least one parameter selected from cardio performance, muscular performance, overall performance, time, date.

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- 25 Preferably comparing the at least some of the first activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the at least some of the first activity data with measurements associated to the at least one parameter monitored during the first activity.

- 30 Preferably comparing the at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the at least some of the second activity data with measurements associated to the at least one parameter monitored during the second activity.

- 35 Preferably the second time interval can be different to the first time interval or can be overlapping.

In another aspect the invention comprises a computer-readable medium having stored thereon computer-executable instructions that, when executed by at least one processor,

cause the at least one processor to perform a method of classifying a plurality of activities associated to a user, the method comprising: receiving first activity data indicative of a first activity performed by the user during a first time interval, the first activity data comprising a plurality of measurements associated to at least one first parameter monitored during the first activity; receiving second activity data indicative of a second activity performed by the user during a second time interval, the second activity data comprising a plurality of measurements associated to at least one second parameter monitored during the second activity, the second activity different to the first activity; comparing at least some of the first activity data and at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium; generating a set of observation alerts based at least partly on the comparison of the first activity data and the second activity data with the respective sets of measurements; comparing the set of observation alerts with respective sets of observation alerts stored on the at least one computer-readable medium; and on detecting a match between the set of observation alerts and at least one set of the stored observation alerts, generating at least one inference alert.

Preferably observation alerts are based on comparisons of measured parameters against thresholds.

Preferably observation alerts are generated when one or both of the first activity data and the second activity data exceeds a threshold, is less than a threshold, or lies within a range.

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- 20 Preferably performance activity is measured by at least one parameter selected from cardio performance, muscular performance, overall performance, time, date.

Preferably environmental activity is measured by at least one parameter selected from temperature, weather forecast, humidity, altitude, terrain.

- 25 Preferably neurocardio activity is measured by at least one parameter selected from posture, respiration, inactive time, heart rate variability, time, date.

Preferably the first activity data comprises a plurality of measurements associated to a first set of parameters monitored during the first activity.

- 30 Preferably the second activity data comprises a plurality of measurements associated to a second set of parameters monitored during the second activity.

- 35 Preferably comparing the at least some of the first activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the at least some of the first activity data with measurements associated to the at least one parameter monitored during the first activity.

Preferably comparing the at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the

at least some of the second activity data with measurements associated to the at least one parameter monitored during the second activity.

5 Preferably the second time interval can be different to the first time interval or can be overlapping.

The term 'activity' includes any bodily action involving use or lack of use of muscles that can be differentiated from another bodily action involving different use of bodily muscles.

10 The invention in one aspect comprises several steps. The relation of one or more of such steps with respect to each of the others, the apparatus embodying features of construction, and combinations of elements and arrangement of parts that are adapted to affect such steps, are all exemplified in the following detailed disclosure.

15 This invention may also be said broadly to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more said parts, elements or features, and where specific integers are mentioned herein which have known equivalents in the art to which this invention relates, such known equivalents are deemed to be incorporated
20 herein as if individually set forth.

As used herein, '(s)' following a noun means the plural and/or singular forms of the noun. As used herein, the term 'and/or' means 'and' or 'or' or both.

25 It is intended that reference to a range of numbers disclosed herein (for example, 1 to 10) also incorporates reference to all rational numbers within that range (for example, 1, 1.1, 2, 3, 3.9, 4, 5, 6, 6.5, 7, 8, 9, and 10) and also any range of rational numbers within that range (for example, 2 to 8, 1.5 to 5.5, and 3.1 to 4.7) and, therefore, all sub-ranges of all ranges expressly disclosed herein are hereby expressly disclosed. These are
30 only examples of what is specifically intended and all possible combinations of numerical values between the lowest value and the highest value enumerated are to be considered to be expressly stated in this application in a similar manner.

In this specification where reference has been made to patent specifications, other
35 external documents, or other sources of information, this is generally for the purpose of providing a context for discussing the features of the invention. Unless specifically stated otherwise, reference to such external documents or such sources of information is not to be construed as an admission that such documents or such sources of information, in any jurisdiction, are prior art or form part of the common general knowledge in the art.

The term 'connected to' includes all direct or indirect types of communication, including wired and wireless, via a cellular network, via a data bus, or any other computer structure. It is envisaged that they may be intervening elements between the connected
5 integers. Variants such as 'in communication with', 'joined to', and 'attached to' are to be interpreted in a similar manner. Related terms such as 'connecting' and 'in connection with' are to be interpreted in the same manner.

The term 'computer-readable medium' should be taken to include a single medium or
10 multiple media. Examples of multiple media include a centralised or distributed database and/or associated caches. These multiple media store the one or more sets of computer executable instructions. The term 'computer readable medium' should also be taken to include any medium that is capable of storing, encoding or carrying a set of instructions for execution by a processor and that cause the processor to perform any one or more of
15 the methods described above. The computer-readable medium is also capable of storing, encoding or carrying data structures used by or associated with these sets of instructions. The term 'computer-readable medium' includes solid-state memories, optical media and magnetic media.

20 Although the present invention is broadly as defined above, those persons skilled in the art will appreciate that the invention is not limited thereto and that the invention also includes embodiments of which the following description gives examples.

BRIEF DESCRIPTION OF THE DRAWINGS

25 Preferred embodiments of the invention will be described by way of example only and with reference to the accompanying figures, in which:

Figure 1 shows exemplary analysis engine, data acquisition, and data analysis
30 components.

Figure 2 shows an embodiment of the analysis engine of figure 1.

Figure 3 shows disparate activities that occur in a day where data is monitored and where inferences can be drawn from multiple data observations that occur.

35 Figure 4 shows how an Observation Alert is generated

Figure 5 shows how inferences can be drawn from observed activities.

Figure 6 shows observation alert pre set or system learned thresholds and the combination of parameters that can be used to create an inference.

5 Figure 7 shows how the observations can be drawn from one day's activity, weeks of activity, months of activity, and years of activity, activity over a sporting careers or for a defined period of activity.

Figure 8 shows how an inference can be drawn from an observation alert, a benchmark metric, a plan metric and a historic metric.

10

Figure 9 shows the differences between an Activity, Activity Types and Activity Conditions.

15 Figure 10 shows the necessary information to create an Inference Alert with a known Activity, Activity Type or Activity Condition, parameters measured, thresholds used, Observation Alerts and Inference Alerts.

20 Figure 11 shows which parameters are potentially used, their metrics, thresholds and the sensor associated with the parameter across a number of activity measurement categories.

Figure 12 shows how an inference alert could be generated from multiple observation alerts that indicate that a user is over training.

25 Figure 13 shows how an inference can be drawn regarding poor sleep habits and the necessity to be ready for a bust working day tomorrow using multiple observation alerts.

Figure 14 shows how an inference that a user has a very high workload can be determined from multiple observation alerts.

30

Figure 15 shows an inference that a user has high fatigue levels because they are training too hard based on observation alerts.

35 Figure 16 shows multiple observation alerts that indicate optimal training rest balance as an inference.

Figure 17 shows an ability to draw a subtle differentiation and therefore inference in fatigue in that a user is exercising well but needs an off season based on a broad number of observation inputs.

Figure 18 shows multiple observation alerts combining to provide an inference of user muscular fatigue.

- 5 Figure 19 shows subtle differentiations in an inference where multiple competing observations show too much exercise intensity and not enough balance between exercise training types.

- 10 Figure 20 shows an inference that a user is training too much based on multiple observation alerts.

Figure 21 shows multiple observation alerts pointing to an inference that a user is too inactive.

15 **DETAILED DESCRIPTION**

1. Virtual Coach Inference Engine Overview

- With the wealth of measured data on user activity currently available there is an opportunity to provide insights to a user in the form of alerts or advice. This data is measured with specialised biometric devices and uses sensors in specific and unique ways. There are many patterns in life that go unnoticed due to the difficulty in drawing a cause effect relationship based on information that is widely spaced in time and disparate in activity. Often data is siloed in different locations on different devices and the large magnitude contextualisation of this data through classification is very useful to discover previously unnoticed insights in health and activity.

- 25 Figure 1 shows an exemplary diagram of a user 100 exercising or engaging in one or more activities, for example engaging in an activity session. The user 100 wears one or more parameter sensing devices 102. Examples of sensing devices include one or more of Heart Rate (chest strap or optical), GPS, speed foot pods, cycle sensors, rowing and kayaking sensors, Accelerometry, fused 9 axis data (accelerometer, magnetometer, gyroscope), ECG, Blood Pressure (direct or optical), Oxygen Saturation, power meters, Equipment ID transmitters, inclinometers, pressure sensors, wind sensors, temperature and humidity sensors, respiration, electromyography and EEG sensors, barometers, DEM, and/or hydration sensors..

- 35 The device(s) 102 collect information on the activity session and in particular data streams associated with the parameters required to classify the activities performed during the user's exercise/activity session.

In an embodiment, device(s) 102 automatically process the data 'on board', or manually when the user prompts the device to process the data for example, if the classification system is housed within the monitoring device(s).

5

Alternatively or in addition the data are transmitted to an analysis engine 104 (which may reside in a remote server or a home computer), either wirelessly or via cables, and if sent to a remote server preferably e.g. via a network. The analysis engine 104 is connected to a memory 106 in which at least some of the data is stored.

10

Instead of automatic transmission of the data, the user may upload the data manually to a desktop or laptop computing device 108 connected to the analysis engine 104 via a wired or wireless network 110.

15

Analysis engine 104 processes the data by accessing memory 106 containing classification system algorithms, threshold criteria and/or user information. These components are described in more detail below. Analysis engine 104 determines activities conducted and the level of performance as described below. It will be appreciated that the analysis engine 104 additionally or alternatively accesses at least one memory associated to sensing device(s) 102, computing device 108, and/or a server on which the analysis engine 104 is maintained.

20

In an embodiment, analysis engine 104 interprets the retrieved data and/or any other data provided by the device(s) 102 to provide feedback to the user 100. In an embodiment the analysis engine 104 alters a training program maintained for example in memory 106. In an embodiment the analysis engine 104 communicates with at least one computing device or other device of the user 100 using a wired or wireless network.

25

Figure 2 shows an example of the analysis engine 104 from Figure 1. An identification engine 200 receives sensor data directly or indirectly from sensing device(s) 102. The identification engine 200 is configured to, in real time or post activity, identify Activities, Activity Types or Cardiovascular and cardiac Events.

30

Data of a user 100 is measured during an activity session or during their activities over a period of time like a day or many days. Multiple data parameters are recorded during this time using one or more data measurement devices.

35

Once the identification engine 200 identifies an Activity, Activity Type or Cardiovascular and cardiac Event, a data analysis engine 202 receives the data from the identification

engine 200. The data analysis engine 204 applies algorithms to provide comparisons between the data.

5 These comparisons are provided to an observation engine 204, an inference engine 206 and an insights engine 208 in order to provide insights to a user. Insights include adjustments to a Training Program/Plan or Activity Schedule and/or information that the user can use to modify their current or future behaviour.

10 A feedback module 210 provides information and/or alerts to a user as will be further described below.

The analysis engine 104, and various components of the engine, are further described below.

15 An overview of a preferred method and inference engine for analysing activity is shown. Figure 3 illustrates data mapped against multiple activities. Examples of multiple activities include exercise activity 300, sleep activity 302, exercise plan & log 304, and general activity 306. This means that the activity is known and the data is recorded and logged within the identified classification. An identified classification involves at least the
20 inference engine knowing the activity and data from one or more parameters.

The data present in each classified activity can be analysed to draw out meaningful metrics. The meaningful metrics are often compared to similar historic data that has occurred within an activity session or at a previous point in time which has a threshold or
25 zone that relates to it.

The data might also be compared to a Plan metric threshold or zone meaning that an Activity Plan or Training Plan with metrics that describe its execution are compared to a user's data. Data may also be compared to benchmark metric thresholds or zones
30 meaning data that has been set independent of a user's historic values. This might include an optimal stride rate threshold of 88 strides per minute regardless of the user's previous stride data. These meaningful metrics are referred to as observations.

Referring to figure 4, if an observation metric 400 is significant enough 402 reaches a
35 critical threshold or zone 404 that has been pre-set or the inference engine has learned, an observation alert occurs 406. If the observation metric is not significant and does not exceed the threshold, then no observation alert occurs 408.

Referring to figure 5, when multiple observation alerts occur 500, an inference can be determined 502. Referring to figure 6, the inference engine tries to find a match with pre stored classifications 600 to draw inferences 602 based on multiple observation alerts 604. Referring to figure 7 the observation alerts 700 can occur over any time period from a single day 702 to a week 704 to a month 706 or to a year, pre-defined time period or throughout the full length of using the inference engine.

Each observation alert must occur at a different time but may overlap and involves different activities, as indicated at 708, 710, and 712.

10

Referring to figure 8, inference engine 206 is configured to generate observation alerts 800 with historic metrics 802, Plan metrics 804 and benchmark metrics 806.

Historic metrics include all past data and calculations based on past data. Plan metrics include metrics and zones to be used in a plan, specific exercise activity plans (e.g. bench press, push ups, shuttle runs), workout plans, training plans/programs or long term plans that last over 3 months. Benchmark metrics include ideal zones, other user comparisons, and goal or target metrics.

20 An output of a match across a number of observation alerts promotes an inference alert that can be provided to a user in an auditory form, as a graphic or colour or as text.

2. Description of the Process to Draw an Inference:

a. Known Activities, Activity Types, Activity Events and Activity Conditions:

25 In each case, either the Activity, Activity Type, Activity Events or Activity Condition must be known. An Activity involves varying modes of limb, muscular and bodily movements or situations where no movement occurs. Postural body incline is also a factor. An Activity Type is a sub class of an Activity where it describes subtle distinctions between types of movement within an Activity. Activity Events are points in time of significance (e.g. bed time, arrival time at home or work, waking time) or key information like appointments, work out plans, training plans or activity plans. Activity Events can use one or more Activity Conditions. Activity Conditions are the parameters used to describe an Activity, Activity Type or Activity Event.

35 In Figure 9 the Activity 900 is Cycling, the Activity Type is Easy 902 and the Activity Conditions are heart rate 904, cadence 906, and altitude change/terrain 908.

Acquiring information so that we have known Activities, Activity Types or Activity Conditions can be achieved two ways:

- Manual Input
- Automatic Detection

5 Manual Input occurs where a user engaged in exercise or an activity inputs the activity in which they are engaged into a device which may be a phone, computer or specialised device. They may choose to input cycling, yoga, working at my desk or fishing as examples.

10 Automatic detection involves using sensor data to determine the activity the user is engaged in. Automatic detection includes using an accelerometer to infer that the user is lying down at a time that is around their usual bed time to start sleeping and determining that the user is moving very little over an extended period of time. More complex forms of detection involve contextualizing user location via GPS, limb movement
15 and position using combinations that could include one or more of accelerometers, gyroscope and magnetometer, posture using accelerometers and proximity to known sensors specific to an activity or a radio frequency tag.

For example, if a user is walking this can be detected by measuring stride rate via an
20 accelerometer with a value of less than 70 strides (140 steps) per minute. It can also be detected by determining the speed to be lower than 7km/hr. Another accelerometer can detect posture with the inclinometer function of the accelerometer indicating that the user is standing upright. Other sensors that can help infer the user's walking activity include heart rate monitors configured to detect between 40 and 50 percent of maximum
25 heart rate.

If the user were to get on a bike the accelerometer stride impact pattern would reduce and speed would increase to above 20km/hr. GPS may show that the user is consistently following a route that matches the location and paths of streets. The detection aspect of
30 the inference engine may also detect that a cycle speed sensor and a cycle cadence sensor are now in close proximity and data from these sensors is being acquired. If the user has a cycle power meter, this data also helps confirm that the user is now riding a bike. Data can now be recorded.

35 An Activity can be defined as an Activity or a sub class of an Activity like an Activity Type or Activity Event.

Different Activities (Activities, Activity Types, Activity Events and Activity Conditions) mean different effort levels or muscle activity including inactivity or a different postural behaviour.

- 5 The Inference engine requires a plurality of Activities and/or, Activity Types and/or Activity Events made up of Activity Conditions occurring at different time intervals to draw inferences.

b. Data is Logged Within the Identified Classification:

- 10 Figure 10 shows that once the Activity, Activity Type (for example 'Running' combined with 'up a Hill'), Activity Event or Activity Condition has been detected, the inference engine measures, records and logs the data as a data segment until a new activity is detected. In an embodiment this involves a metric or data set for one or more streams of data obtained from one or more sensors. For example a user may engage in walking for
15 30 minutes and then cycle for 20 minutes. In each case, the activity is identified, labelled and all the data that is produced by the sensors in use is recorded and logged for current or later analysis. This data may involve GPS, accelerometer, barometric, inclinometer, gyroscope, magnetometer, heart rate, speed sensor, limb turnover, power, ECG, and blood pressure data for example. A wealth of data is now available in a discrete segment
20 where algorithms can now be applied to further clarify what is happening within the activity.

Data may be obtained as a single data point or as many data points either in a single stream or multiple data streams.

- 25 There are 2 types of activity classification. The first is distinguishing between activities like cycling, walking, running, rowing and lying down. The second is a subtler interactivity classification where different types of running or cycling are detected. This might include sprinting, climbing a hill and moving along at an easy pace for cycling or
30 running.

c. Observations are Established Based on the Identified Classification:

- Observation alerts are indications of the presence of significant data based on a parameter or multiple parameters passing a pre-set or machine learned threshold,
35 entering a zone or matching a value. With clear segments of data which can be associated to an activity, metrics can be determined to give the streams of data more meaning. This could be as simple as determining the average pedal cadence for the cycling segment or determining the standard deviation for pace for a runner aiming to

run a perfectly paced run. They could also be as simple as the duration a user slept overnight. More complex multi parameter algorithms can be applied to the data segment to ascertain information such as quality of sleep, fatigue levels, and quality of an activity or workout.

5

For example, the amount of movement an accelerometer detects during sleep provides good insights into sleep quality. Likewise, in a gym context, the rate of movement of a lifted weight in an exercise like a seated row gives insights to poor technique by lifting a weight too rapidly and whether the user is cheating in their technique by resting between lift repetitions.

10

Multi Segment summaries and inter segment comparisons are also useful. Multi segment summaries might include comparisons within the workout like the fact that the power output of the cyclist on each successive hill climb data segment is deteriorating at 10 watts per hill.

15

Comparisons can also be made between current data and historic data like an exercise data segment completed 2 months ago or a year's best result. For example, the current observation data of number of vertical meters in a single run may be compared to the personal best for this metric or it may be compared to last week's results for the same metric.

20

Comparisons can be used to determine exercise compliance to a workout plan where the number of hill climbs detected can be compared to the planned number of hill climbs for the workout.

25

Benchmark comparisons can also be used where a user's stride rate in running can be compared to the 'gold standard' stride rate that is expected.

In each case a first, second or more Activities, Activity Types or Activity Conditions are used with each potentially generating one or more observations.

30

d. The Observations Are Compared to Data Thresholds:

Observations and Observation data can be compared to historic data or metrics, benchmark metrics and Plan metrics to obtain a meaningful metric.

35

Comparisons:

Comparisons are made by comparing one or more Observation metrics 815 or data sets with other metrics and data sets.

There are four kinds of comparisons for Observation metrics:

- 5 • Historic Data or Metrics: metrics from analysis of past Activity or Activity Type data sets.
- Benchmark Metrics: metrics that are preset and involve no historic data.
- Plan Metrics: metrics about an Activity Plan or Exercise Plan
- Learned activities, behaviors and responses (through machine learning)
- 10 • Other Observation Metrics or data

Other metrics could also be included.

Comparisons are made where at least some of the activity data from a first, second or more activities are each compared with respective sets of measurements stored on a
15 tangible computer readable medium. An Activity or Activity Type comprising a first activity for example as distinct from other activities may contain multiple parameter streams of data. At least some of the parameters may be compared to stored measurements which include historic data, benchmark data, plan metrics and other observation metrics. In each case at least some of the activity data is compared with
20 measurements associated to at least one parameter in the activity data.

Thresholds and Zones:

The metrics are then applied to a threshold or zone 820 to determine if the observation
25 warrants an alert. The thresholds and zones can be pre-set by the user or they can be learned by the detection aspect of the inference engine based on set criteria by the user. The learning occurs based on multiple instances of data where the inference engine determines via automated calculations, algorithms, statistical analysis and machine learning. This metric may become a threshold or have further calculations applied to
30 establish a zone.

Observations become Observation Alerts when they move to being above or below a threshold. Observations can also move to Observation Alert status if they go into or out of a zone. This includes both going below or above the zone.

35

Multiple Activities, Activity Types, Activity Events or Activity Conditions making up a first, second and or more activities where metrics from these activities are compared to respective sets of measurements stored in a tangible computer readable medium.

Observation thresholds may be manually input or utilise methods like machine learning and statistical methods.

- 5 Observations may use fuzzy thresholds where not all parameters are meeting defined thresholds but there are enough within thresholds or close to thresholds for the Inference Engine to infer an Observation.

e. Observation Alerts:

- 10 Once an Observation Alert 825 has occurred it remains as part of the historic data and metrics going into the future. This is because the Inference Engine needs to be able to refer back to the user's historic data and look for patterns in the data based on Observation Alerts. In a simple example, the inference engine may look back for the best result in an Activity or Activity Type in the last week, last month or last year for
15 comparisons with current data.

Observation Alerts are based at least partly on comparisons where a first, second or more activities are compared to their respective sets of measurements.

20 **f. Inference Alerts:**

An Inference Alert are indications of the presence of significant data, which occurs when more than one Observation Alert occurring at different times or dates, match a pre-set or machine learned threshold or thresholds, enters a zone or zones or matches a value or more than one value.

.25

Multiple Observation Alerts Match Pre Stored Configurations:

- The inference engine is designed to look for matches within multiple Observation Alerts based on pre-set classifications. When the pattern of multiple Observation Alerts conforms to a pre-set pattern stored in the memory of the Inference Engine, a match is
30 detected and an Inference Alert is generated. This means the conditions are met for each Observation Alert 830 to generate in Inference Alert. 835

Observation Alerts are Time Separated:

- The inference engine uses Activity, Activity Type and Activity Condition data that is
35 separated in time but data sets may overlap.

Observation Alerts involve Different Activities, Activity Types or Activity Conditions:

The purpose of the Inference Engine is to look for patterns in user activity behaviour and therefore requires more than one activity, activity type or activity condition to make an inference.

- 5 In summary, Inference Alerts are based on comparing a set of Observation Alerts with respective sets of Observation Alerts stored in a computer readable medium and where detecting a match between the set of Observation Alerts and at least one set of stored Observation Alerts, a processor generates an Inference Alert.
- 10 Inference Alerts may use fuzzy thresholds where a match in pre stored observation alerts and actual observations may not be exact but there are enough matches or near matches to warrant the inference alert.

- Inference Alerts may be manually input or may utilise machine learning and/or statistical
- 15 techniques to establish their criteria.

g. Inference Classifications and Higher Order Inference Alerts:

- Once Inference Alerts and their matching multi Observation classification are generated, they are retained as historic information. This allows a higher order Inference engine
- 20 based on applying thresholds and zones to a number for previous historic inference alerts. If conditions are met for a number of Inference Alert metrics or data sets and they conform to a pre-set pattern or set of conditions stored in the devices memory, then a Higher Order Inference Alert is generated. Potentially there are several more orders of magnitude for Inference Alerts that can occur each with an Inference Engine and a set of
- 25 grouped pre-set stored thresholds or zones that forms a pattern based on past inference alerts that the Inference Engine can detect.

h. Inference Alert Outputs

- Once an Inference Alert is generated, the Inference Engine can refer to a library of
- 30 possible actions:

- Auditory Advice Output
- Auditory Signal Output
- Dynamic Updating of an Activity or Exercise Plan Output
- Graphical or Metric Output
- 35 • Text Output

It is also possible that an audio visual output could be generated.

Auditory Advice Output:

- The Inference Engine may supply 'advice' in an auditory manner. This might be to advise the user that the reason for their fatigue is linked to a lack of good quality sleep measured through the amount of motion while a user is asleep and going to bed too late
- 5 measured by the time in the evening that the user is in a lying position with low levels of motion for more than 3 hours. This information around sleep habits being linked to fatigue could be supplied through a speaker or headphones.

Auditory Signal Output:

- 10 The Inference Engine could generate a signal that has an attached meaning to the user. For example, a low pitched 'beep' might tell the user they are tired and a high pitched 'beep' might indicate good recovery and a 'fresh' status.

Dynamic Updating of an Activity or Exercise Plan Output:

- 15 The Inference Engine can update an Activity Plan or an Exercise Plan based on inferences made through collection of Observation data. For example, lack of good quality sleep, going to bed too late and fatigue could cause the Inference Engine to adjust an Exercise Workout Plan the following day to be easier to accommodate the low energy levels.

20 Graphical or Metric Output:

Fatigue detected by the Inference Engine could be output graphically by using a 'fuel tank graphic showing that the level of the 'fuel tank' is low or by using the colour red to characterise fatigue. A metric could be provided that has a high score when the user is fresh and recovered and a low score when the user is fatigued.

25

Text Output:

- Information based on an Inference Alert can be output in text. The Inference Engine may output 'You are fatigued due to poor quality sleep over the last few nights and going to bed too late. I have adjusted the workout for tomorrow to be easier and suggest that you
- 30 do it in the afternoon so you can sleep in.' based on sleep quality values, sleep time values and fatigue measures.

3. Activities, Activity Types and Activity Conditions:

- There are several ways the Inference Engine can analyse the data. Data can be
- 35 measured for

- Activities
- Activity Types
- Activity Events

- Activity Conditions

An Activity involves varying modes of limb, muscular and bodily movements or situations where no movement occurs. Postural body incline is also a factor.

An Activity Type is a sub class of an Activity where it describes subtle distinctions

5 between types of movement within an Activity.

Activity Events are snapshots of data for a specific event that occurs such as arriving home from work, an ECG anomaly, atrial fibrillation, significant blood pressure fluctuations. In each case the time period that an Activity Event occurs over is much shorter than an Activity or Activity Type and an Activity Event is independent of an

10 Activity or Activity Type.

Activity Conditions are the parameters used to describe an Activity, Activity Type or Activity Event. Therefore, Activity Conditions involve one or more data parameters to describe an Activity Type. One or more Activity Types are used to describe an Activity. Different Activities, Activity Types and Activity Conditions may be referred to as a first
15 activity, second activity, through to a significant number of activities.

- a. Activities:

Activities describe a type of physical action that a user might be engaged in. These can include:

- 20 • Walking
- Running
- Cycling
- Rowing
- Swimming
- 25 • Kayaking
- Skating
- Cross Country Skiing
- Sitting
- Standing
- 30 • Lying down (side, front, back)
- Travelling (motorized)

There are many ways of increasing the granularity of Activities and Activity Types so the information provided does not limit the scope in terms of Activities, Activity Types or Activity Conditions. For example, proximity sensing can be combined with upper and
35 lower body limb motion and incline, postural incline and proximity to various inanimate objects or even people or animals. Potentially geo-fencing could also be applied. Use of an ambient light sensor can if the user is in dark conditions where the lights are off at

night, while other sensors show that the user is lying down, the time is 3 am and still other sensors show the user has sleep apnoea.

b. Activity Types:

- 5 Within these activities, a further granularity can occur by determining subtle differences in the way an activity is conducted which are known as Activity Types. For example, a runner can be running easy on the flat, running easy up a hill, running fast on the flat or running fast up a hill. The differentiation is that not only is the runner running, they are also running up a hill as opposed to other granular possibilities like running downhill, or
- 10 running on the flat. A more sophisticated form of Activity Types might be cycling on the flat in a big gear at 60-75% effort at a cadence of 65 to 75 pedal revs per minute which might be called a Flat Big Gear Activity Type. The cyclist might be riding at 88 to 92 pedal revs per minute at 80 to 90% of maximum heart rate on the flat. Three granular distinctions are made here in that the cyclist is not only cycling, they are cycling at a low
- 15 effort, at a low cadence on the flat. In both cases the user is cycling and is cycling on the flat but there are subtle differences in their activity which can be defined by Activity Types. Activity Types are subtle distinctions within the same Activity.

Simultaneous Multi-Parameter Nature of Activity Types

- 20 Activity Types require more than one parameter to describe them. Each parameter has a pre-set threshold or zone that it must activate to detect an Activity Type. Each parameter must drop below the threshold, exceed the threshold, go into a zone or out of a zone to activate the parameter for an Activity Type detection and classification.

This must occur for more than one parameter that is used to describe the Activity Type.

- 25 This means that at least two parameters have been simultaneously activated for detection to occur and that they conform to a pre-set stored classification pattern that confirms a particular Activity Type which can then be classified. Examples will be described shortly. Parameters can be sampled continuously and simultaneously or each parameter can be sampled alternately.

30

An Activity Type, Activity Event or Activity can involve a plurality of measurements associated with it but in the case of an Activity or Activity Event it is possible to have only one parameter.

- 35 Data and metrics for different Activities, Activity Types and Activity Events or multiple occurrences of the same Activities, Activity Types and Activity Events used for Observations are drawn from different time intervals.

Time intervals are defined as a time of day, elapsed time, day of week, month of year, year and any derivations or further configurations or ways of segmenting time.

c. Activity Events

- 5 Activity Events are snapshots of data for a specific event that occurs such as arriving home work, an ECG anomaly, atrial fibrillation, significant blood pressure fluctuations. They are not Activities or Activity Types that must occur over a time period that is long enough to show intention for the Activity or Activity Type. Activity Events are either moments in time where something significant occurred to the user (e.g. arrival at work,
- 10 waking time) or something that happens to the individual. (e.g. ECG anomaly or atrial fibrillation). In the case of something happening to the user, it is not the 'doing of the user', it is something that is happening or 'doing' to the user.

d. Activity Conditions: Parameters used for the Inference Engine

- 15 Activity Conditions involve the use of parameters to describe an Activity or Activity Type. These parameters might include an effort parameter like heart rate, a terrain type like altitude change, a posture parameter that determines the user is upright and a stride rate parameter to determine that the users stride is high enough to infer that they are running.

20

An Activity can occur without incorporating an Activity Type. An Activity Type must always describe a subtler distinction of an Activity. An Activity Event does not necessarily need to include or be part of an Activity or Activity Type although in most cases it is.

- 25 The Activity Conditions that can be used to describe any Activity, Activity Type or Activity Event used in this Inference Engine are:

Effort Parameters:

- Muscular Effort Parameter Class:
 - 30
 - Power output,
 - Energy expenditure/ Energy Consumed (including specific foods)
 - lifted weight, (including body weight including speed of movement & acceleration)
 - acceleration,
 - 35
 - force generated,
 - distance per limb turnover (e.g. stride length, distance per stroke),
 - or electromyography values. (muscle contraction, recruitment & use)
- Speed and Work Parameters:

- speed,
 - pace,
 - energy expenditure,
 - energy intake,
 - 5 ○ body weight,
 - including detections where no work or speed is occurring.
- Biomechanical Parameters:
 - vertical oscillation during walking or running,
 - foot strike impact,
 - 10 ○ time on the ground of the foot in running or walking
 - and foot strike patterns (e.g. pronation, supination, heel strike, forefoot and midfoot strike)
 - limb turnover (e.g. stride rate, pedal cadence, stroke rate)
 - distance per limb turnover (e.g. stride length, distance per pedal turn
 - 15 or stroke)

Response Parameters:

- Cardiorespiratory and Neurocardio Parameters:
 - heart rate,
 - heart rate variability (including SD1, RMSSD),
 - 20 ○ respiration rate or pattern,
 - ventilation,
 - oxygen uptake
 - and oxygen saturation. (e.g. blood and muscle)
- Biomedical Parameters:
 - 25 ○ body temperature,
 - blood glucose,
 - blood cholesterol,
 - Blood Pressure,
 - ECG, including ECG feature extractions such as the peak amplitude,
 - 30 area under the curve, displacement in relation to baseline of the P, Q, R, S and T waves, the time delay between these peaks and valleys, and heart rate frequency (instantaneous and average).
 - EEG waveform
 - and hydration levels or inferred levels of dehydration.
- 35 • Performance Parameters:
 - Cardiovascular Performance,
 - Muscular Performance,
 - Neurocardio Performance

Environmental Parameters:

- Terrain and Location Parameters:
 - altitude,
 - slope,
 - 5 ○ gradient,
 - incline
 - user location,
 - location of a target object,
 - heading
 - 10 ○ direction a user is travelling,
 - direction a user is facing.
 - Environmental Parameters:
 - temperature,
 - humidity,
 - 15 ○ barometric pressure,
 - heat index,
 - local wind speed,
 - local wind direction,
 - apparent wind speed and direction
 - 20 ○ local rain
 - ambient light (detecting night and day and potentially overcast conditions.)
 - and local altitude.
 - weather forecast – rain, wind, temperature, humidity
- 25 Activity/Exercise Plan Activities:
 - Plan Parameters:
 - Planned Duration,
 - Planned Exercises/Activities,
 - Planned Exercise/Activity Durations,
 - 30 ○ Planned Exercise/Activity Repetitions,
 - Planned Exercise/Activity Rest Periods
 - Current workout relationship to high training volume week, race date, planned taper week
 - Executed Exercises Parameters:
 - 35 ○ Exercise/Activity Compliance,
 - Exercise/Activity Repetition Number,
 - Exercise/Activity Resistance Value,
 - Exercise/Activity Speed of Repetition Values (lift & lower),

- Exercise/Activity Rest Period Number,
 - Exercise/Activity Rep Intensity,
 - Exercise/Activity Intensity,
 - Exercise/Activity Volume (distance/duration)
- 5 • Exercise Behavior Parameters:
 - Time of day an activity occurs
 - Number of times an activity occurs consecutively
 - Relationships between occurrences of different activities
 - Exercise Pattern in a week
- 10 Life Parameters:
 - Posture Parameters:
 - Standing,
 - Sitting
 - and Lying Down
 - 15 ○ Postural Status – Leaning
 - Postural Status – Slouching
 - Postural Status – Bending over
 - Postural Status – lying on back
 - Postural Status – lying on front
 - 20 ○ Postural Status – lying on right side
 - Postural Status – lying on left side
 - Movement Patterns
 - Vertical impact
 - 25 ○ Horizontal impact
 - Arm horizontal punching
 - Arm above head, vertical punch
 - Arm above head down laterally to waist
 - Arm above head, down frontally to waist
 - 30 ○ Arm wind milling forward/back
 - Arm bend at elbow straight to shoulder
 - Knee bend, knees together
 - Knee bend, legs wide
 - Lateral leg swing
 - 35 ○ Frontal leg swing
 - Heel to buttock leg curl
 - General Activity Parameters:

- Steps/time
 - Upper body Limb movement/time
 - Rate of steps or limb movement
 - Vertical ascent (walking/running)
- 5
 - Calendar Parameters:
 - Appointment Occurrence,
 - Appointment Times,
 - Appointment Duration,
 - Appointment Location
- 10
 - Travel Parameters:
 - Location/Time Zone,
 - Work Location,
 - Home Location,
 - Average Travel Time
- 15
 - Average Leave for Work Time
 - Average Leave for Home Time
- General Behaviour Patterns:
 - General Activity Pattern within a week
 - Travel Pattern within a week
- 20 Recuperative Parameters:
 - Sleep Parameters:
 - Bed/Sleep Start Time,
 - Wake Time,
 - Sleep Duration,
 - 25 ○ Deep Sleep Duration,
 - Light Sleep Duration
 - Awake lying down
 - Asleep standing
 - Asleep sitting up
 - 30 ○ REM sleep duration
 - Sleep phases 1, 2, 3 and 4
 - Neurocardio Measures:
 - Heart rate Variability (RMSSD RR interval, AVNN, SDNN, SD1, SD2,
 - 35 HF, LF, HF/LF, RMSSD, lnRMSSD, pNN50, and Total Power.
 - Equipment ID
 - RFID tags
 - Sensor labels for Ant+ and Bluetooth (low emission)

For all the above parameters, changes in measures of these parameters are also included.

A single Activity Condition may be used to describe an Activity or multiple Activity

5 Conditions may be used simultaneously.

There are a number of parameter constraints:

- 2 axes from the same sensor do not represent 2 parameters. They are a combined motion parameter (e.g. the x axis and y axis of either an accelerometer, a gyro meter or a magnetometer are not 2 parameters. In this definition they equate to a single motion parameter.)
- 2 parameters can be obtained from the same sensor (e.g. incline and footfall impact)
- The same parameter can be used more than once simultaneously but they must utilize separate sensors. (e.g. incline from the accelerometers located on different parts of the body)

Ideally when sensors are available stress and nutrition parameters would also be included. The inference engine can be told what the activity is by manual input or can determine the activity automatically.

20 The above parameters are not limited to what is disclosed and serves more to show some possible metrics that can be used by the inference engine.

Inferred data and derivations of these parameters are also included.

4. Detection of Activity and Activity Types Using Activity Conditions:

25 a. Details of Activity Detection

As described above, activities can be detected in 2 ways; manually or automatically.

Manual Activity Detection:

Manual Activity Detection involves a user manually time stamping the beginning, end or both, of a data segment and the potentially inputting the label, code or description of the Activity that they are or were engaged in. This input could be into a computer remote to the Activity in location, connectivity or time. It could also be a mobile 'all in one' purpose built measurement device.

35 Automatic Activity Detection:

Automated Activity detection involves the Inference Engine sensing the Activity. These can be achieved via sensing a single parameter or by contextualising the Activity from multiple parameters.

Single Parameter Sensing: Determining the Activity from a single parameter is very easy to achieve in that the Inference Engine can determine the Activity based on the sensor it is picking data up from. A further confirmation of the Activity can occur when the

- 5 Inference Engine receives data that is consistent with the predicted Activity. For example, sensing cycle sensors like speed and cadence can be confirmed when the speed exceeds 20km/hr and the cadence is above 60 revs per minute.

Multiple Parameter Sensing: Using multiple sensors to contextualise an Activity can occur where the sensor identification information does not provide adequate information on the Activity's identification. In this case a number of sensors and their data can be used to confirm the Activity.

A GPS speed of below 7km/hr with measures of accelerometer decelerations that are consistent and occur at 130 heavy decelerations per minute of greater than an impact threshold may indicate walking whereas a speed of 25km/hr without consistent decelerations and with decelerations of less than the impact threshold may indicate cycling. Other context parameters for cycling may include following the path of known roads on a digital map, stopping at street corners on the map, an upper body postural incline that is bent forward and not upright could also be used.

20

Single Parameter Sensing might include one of the following:

Each Activity has at least one Activity Condition that is supporting it.

Walking

- 25
- Accelerometer Decelerations (greater than a set threshold) below 140 per minute
 - Speed between 0 and 7km/hr (GPS, footpod)
 - Walking Sensor ID (sensor has unique ID)

Running:

- 30
- Accelerometer Decelerations (greater than a set threshold) greater than 140 per minute
 - Speed between 7 and 22km/hr (GPS, footpod)
 - Running Sensor ID (sensor has unique ID)

Cycling:

- 35
- Cycling Sensor ID (sensor has unique ID)
 - Motion pattern is consistent with Cycling (accelerometer or 9 axis sensor)
 - Power Sensor or sports equipment inclinometer present

Rowing:

- Rowing Sensor ID (sensor has unique ID)
- Motion pattern is consistent with Rowing (accelerometer or 9 axis sensor)
- Impeller or rowing stroke rate sensor is present

Swimming:

- 5
- Swimming Sensor ID (sensor has unique ID)
 - Motion pattern is consistent with Swimming (accelerometer or 9 axis sensor)
 - Swimming stroke rate sensor is present

Kayaking:

- 10
- Kayaking Sensor ID (sensor has unique ID)
 - Motion pattern is consistent with Kayaking (accelerometer or 9 axis sensor)
 - Impeller or kayaking stroke rate sensor is present

Skating or Cross Country Skiing:

- 15
- Skating or Cross Country Skiing Sensor ID (sensor has unique ID)
 - Motion pattern is consistent with Skating or Cross Country Skiing (accelerometer or 9 axis sensor)

Sitting:

- Lower body (femur) postural incline is near horizontal (accelerometer or 9 axis sensor)

Standing:

- 20
- Body postural incline is vertical (accelerometers or 9 axis sensors)

Lying Down:

- Body postural incline is horizontal (accelerometers or 9 axis sensors)

Travelling (motorised):

- 25
- User is following transport routes including stops at intersections, stations etc. (GPS)

9 axis sensors include an accelerometer gyroscope and magnetometer.

Multiple Parameter Contextualisation would use more than one of the following:

Each Activity has a number of Activity Conditions that support it.

- 30 Walking
- Accelerometer Decelerations (greater than a set threshold) below 140 per minute
 - Speed between 0 and 7km/hr (GPS, footpod)
 - Walking Sensor ID (sensor has unique ID)
 - Postural Incline is Upright (accelerometer or 9 axis sensor)

Running:

- Accelerometer Decelerations (greater than a set threshold) greater than 140 per minute
- Speed between 7 and 22km/hr (GPS, footpod)
- 5 • Running Sensor ID (sensor has unique ID)
- Postural Incline is Upright (accelerometer or 9 axis sensor)

Cycling:

- Cycling Sensor ID (sensor has unique ID)
- Motion pattern is consistent with Cycling (accelerometer or 9 axis sensor)
- 10 • Postural Incline is leaning forward (accelerometer or 9 axis sensor)
- User is following roads, and stops at intersections (GPS)
- Speed is greater than 20km/hr (GPS, Cycle speed sensor)
- Wind Speed is greater than 20km/hr (Anemometer, Pitot tube)
- Power Sensor or sports equipment inclinometer present

15 Rowing:

- Rowing Sensor ID (sensor has unique ID)
- Motion pattern is consistent with Rowing (accelerometer or 9 axis sensor)
- Postural Incline – user is seated (multi accelerometer or 9 axis sensor)
- User is facing backwards to direction of movement (magnetometer)
- 20 • Accelerometer decelerations are between 0 and 45 per minute
- Impeller or rowing stroke rate sensor is present

Swimming:

- Swimming Sensor ID (sensor has unique ID)
- Motion pattern is consistent with Swimming (accelerometer or 9 axis sensor)
- 25 • Postural Incline – user is lying flat or nearly flat (accelerometer or 9 axis sensor)
- Accelerometer decelerations consistent with swimming stroke rate
- User is immersed in water (two sensors use water to complete circuit)
- Swimming stroke rate sensor is present

Kayaking:

- 30 • Kayaking Sensor ID (sensor has unique ID)
- Motion pattern is consistent with Kayaking (accelerometer or 9 axis sensor)
- Postural Incline – user is seated (multi accelerometer or 9 axis sensor)
- Accelerometer decelerations consistent with kayaking stroke rate
- Impeller or kayaking stroke rate sensor is present

35 Skating or Cross Country Skiing:

- Skating or Cross Country Skiing Sensor ID (sensor has unique ID)

- Motion pattern is consistent with Skating or Cross Country Skiing (accelerometer or 9 axis sensor)
- Speed is consistent with Skating or Cross Country Skiing (GPS)
- Postural Incline – user is seated (multi accelerometer or 9 axis sensor)
- 5 • Accelerometer decelerations consistent with skating or cross country skiing limb turnover rate
- Temperature, Time of year and location could also be used for Cross Country Skiing

Sitting:

- 10 • Upper Body Postural incline is upright (accelerometer or 9 axis sensor)
- Lower body (femur) postural incline is near horizontal (accelerometer or 9 axis sensor)

Standing:

- Upper body postural incline is vertical (accelerometers or 9 axis sensors)
- 15 • Lower body postural incline is vertical (accelerometers or 9 axis sensors)

Lying Down:

- Upper body postural incline is horizontal (accelerometers or 9 axis sensors)
- Lower body postural incline is horizontal (accelerometers or 9 axis sensors)

Travelling (motorised):

- 20 • Upper Body Postural incline is upright (accelerometer or 9 axis sensor)
- Lower body (femur) postural incline is near horizontal (accelerometer or 9 axis sensor)
- Speed is above 20km/hr (GPS, Speed sensor)
- User is not in proximity of work or home (GPS)
- 25 • User is following transport routes including stops at intersections, stations etc. (GPS)

Each of these could be referred to as a first activity, second activity or further activities.

b. Details of Activity Type Detection

- 30 Activity Types are described by more than one parameter simultaneously conforming to a set of zones or thresholds that describes an Activity Type. Although the preferential method of sampling of parameters is simultaneous, alternate sampling of parameters could be used.

Any combination of parameters such as speed, heart rate, power, respiration rate, heart rate variability, turnover, distance per turnover, vertical meters ascended, slope, gradient and incline can be used to depict a particular classification as an example.

- 5 Two important measures for Activity Types are effort and resistance measures. These measure the user's cardiovascular and muscular resistance effort. Muscular effort in most activities involves knowing the terrain, distance per limb turnover (e.g. distance per stroke, stride length) or alternatively the limb turnover (e.g. stride rate, pedal cadence) for a given cardiovascular effort (e.g. speed, power, heart rate).

10

Cardiovascular effort usually uses speed, power or heart rate but could also include respiration rate, oxygen saturation and heart rate variability measures. To ascertain effort by measuring speed, power or heart rate they must be individually calibrated to the user. This is because a heart rate of 160 beats per minute represents different effort levels for different people. Likewise, a speed of 12km/hr or a power output of 250 watts also represent different effort levels for different people.

15

20

Heart rate, speed and power thresholds and or zones that represent a cardiovascular effort index need to be established cardiovascularly with a minimum of user work to complete.

25

There are many ways and tests used to define these thresholds or zones for heart rate, speed and power. Different methods include using a maximum value tested or obtained from within training or activity, using the Anaerobic or Aerobic Threshold value, or using averages based on the activity or exercise of the user, using heart rate variability to establish cardiovascular stress, lactate thresholds, ventilatory thresholds, critical power and many more.

30

Anaerobic Threshold is a term that has poor standardisation in sports science literature. In this case, Anaerobic Threshold implies the maximum effort a user can sustain for 20 minutes to one hour. For completeness of explanation, anaerobic threshold may in this case be taken to mean Onset of Blood Lactate Accumulation, Lactate Turn-point, Maximum Lactate Steady State, Critical Power, Function Threshold Power and other terms applied to main the same concept.

35

The above monitored parameters and in particular the threshold criteria are only exemplary and reflect possible embodiments of the invention. They are not intended to

be limiting. It is preferred in fact to have variations on the threshold criteria (and zones) for each individual as the system may be calibrated to their specific ability and needs.

As an example, we can demonstrate how effort zones can be calibrated.

5

Initial Calibration

Exercise, activity or training zones/criteria may to be calibrated to the individual so the zones conform to match correctly what the user experiences. The traditional calculations (e.g. 220- age in yrs and the Karvonen formula) and then percentages set against them which are used to determine the zones are only correct in 60% of individuals so another form of a more individualised assessment is preferably performed during a user's activity. One way to achieve this assessment is to establish what the user's Anaerobic Threshold is in a method that is safe for the user and not too complicated or invasive to the user's activity.

15

Anaerobic Threshold (AT) is a well-known metric in exercise physiology that implies the maximum effort that a particular individual can exercise at for a particular period of time (e.g. 20 minutes to 1 hour) depending on their fitness. This can be at a heart rate of 170-180 beats per minute for one individual with a high heart rate and high Anaerobic Threshold or can be 140 – 150 for an older individual with a low Anaerobic Threshold for example. AT can similarly be measured with speed and power. There are preferably four systems to determine AT due to the fact that it must be compatible across a wide range of hardware platforms each using different sensor data.

25 Heart Rate Calibration System:

The user exercises and their heart rate data is collected each time they exercise and generated into a histogram. The histogram records the number of incidences of a heart rate within a specific range (e.g. 170 – 175). Each range forms an 'incidence bin' that contains a count of all heart rate data that falls between the bins range. Some ranges will be empty with no data and therefore inactive. Of the remaining active incidence bins the highest change in incidences of a heart rate falling into the highest 3 histogram range bins that are activated denotes the 'Anaerobic Threshold' heart rate zone. The system can do this assessment as a calibration workout or can do this for every workout and constantly update itself.

35

Power Calibration System:

The user exercises and their power data is collected each time they exercise and generated into a histogram. The histogram records the number of incidences of a heart rate within a specific range (e.g. 170 – 175). Each range forms an 'incidence bin' that

contains a count of all heart rate data that falls between the range of the bins. Some ranges will be empty with no data and therefore inactive. The highest change in incidences of a power falling into 'histogram bins' in the top 3 histogram bins that are activated denotes the 'Anaerobic Threshold' power zone. The system can do this assessment as a calibration workout or can do this for every workout and constantly update itself. Once again AT power is not the same for everyone, it is highly individualised. This can be at a power of 240 watts for one individual or 120 watts for another for example. In each case the training zones can be extrapolated through algorithms for each intensity level.

Speed Calibration System:

The same system is applied as above to speed with several minor modifications (e.g. speeds are only assessed on the flat) to achieve the same goal.

The same concept may be applied to respiration rate (and some heart rate derivatives including use of Heart Rate Variability, cadence or turnover and distance per turnover)

Once the AT zone has been identified, in each case all the other activity/training zones can be extrapolated through algorithms for each intensity level.

If the AT is assessed for every workout so that it constantly updates which is the preferred embodiment, there are contingencies set for accepting new data that updates the historic AT zone and therefore all other activity zones. Data that falls outside being less than 90% of the maximum historic AT value or more than 105% of the maximum historic AT value is deleted and not used to update the historic AT value which is an average of accepted historic AT values for each workout.

Now that we have calibrated effort to the user we can now set up thresholds and zones based on the effort calibration index. Activity Types are described by multiple simultaneous thresholds or zones that describe an Activity Type.

Here is a description of how Activity Types are described:

1. Walking, i.e. an individual moving at a speed below 8km/hr. One monitored parameter and threshold criterion used to identify an individual walking can be a stride rate of less than 66 strides per minute. Alternatively, or in addition, an effort/intensity measure/parameter more closely associated with the user's own ability may be used to classify walking. The threshold criteria for such a

parameter may be a user heart rate (HR) of less than 60% of their maximum heart rate, and/or of less than 70% of their Anaerobic Threshold (AT) HR. Effort may alternatively or in addition be measured using speed and/or power, in which case the threshold criteria for walking may be less than 60% of the individual's AT speed and/or less than 60% of their AT power respectively. In addition to any combination of the above parameters and their threshold criteria, a flat terrain criterion is required by the classification system to identify a walking activity. In which case, the system may define a flat terrain for walking as an upward slope of less than 2° (or 4% gradient where consistent altitude (allowing for edge forgiveness - discussed in more detail in the Parameters section) cannot amount to more than a 6-meter altitude gain). A downward slope of as much as 8.5° (16% gradient) may also be regarded as a walking activity as would any uphill that fails to qualify as a hill (less than a 6 meter climb).

2. Easy running, i.e. jogging at 8 – 10 km/hr (for most people). One monitored parameter and threshold criterion used to identify an individual easy running can be a stride rate of greater than 70 strides per minute. Alternatively, or in addition, an effort/intensity measure/parameter more closely associated with the user's own ability may be used to classify walking. The threshold criteria for such a parameter may be a user heart rate (HR) of 65 - 75% of their maximum heart rate, and/or of 70 - 80% of their Anaerobic Threshold (AT) HR. Effort may alternatively or in addition be measured using speed and/or power, in which case the threshold criteria for easy running may be 60 - 90% of the individual's AT speed and/or 60 - 90% of their AT power respectively. In addition to any combination of the above parameters and their threshold criteria, a flat terrain criterion may be required by the classification system to identify a walking activity. In which case, the system may define a flat terrain for easy running as an upward slope of less than 2° (or 4% gradient where consistent altitude (allowing for Edge Forgiveness – discussed in more detail in the Parameters section) cannot amount to more than a 6-meter altitude gain). A downward slope of as much as - 8.5° (-16% gradient) may also be regarded as an easy running activity as would any uphill that fails to qualify as a hill (less than a 6-meter climb).

3. Flat terrain muscularly loaded activity (for example a big gear at a low cadence on a bike on the flat) – this classified activity is related to cycling and not walking/running as for the above two. One monitored parameter and threshold criterion used to identify an individual performing a muscularly loaded activity can be a big gear (e.g. 52x16). This parameter may be measured by distance travelled per pedal revolution with a threshold criterion of 65-75 pedal revolutions per minute. Alternatively, or in addition, a threshold criterion of 85 – 130% of the AT distance per pedal turnover may be used. An effort/intensity

- measure/parameter more closely associated with the user's own ability may also or alternatively be used to classify a muscularly loaded activity. The threshold criteria for such a parameter may be a user heart rate (HR) of 65 - 75% of their maximum heart rate, or of 70-80% of their Anaerobic Threshold (AT) HR. Effort may alternatively or in addition be measured using speed and/or power, in which case the threshold criteria for flat terrain muscularly loaded may be 65 - 90% of the individual's AT speed and/or 65 - 90% of their AT power respectively. In addition to any combination of the above parameters and their threshold criteria, a flat terrain criterion is required by the classification system to identify a flat terrain muscularly loaded activity. The system may define a flat terrain for this activity as an upward slope of less than 2° (or 4% gradient where consistent altitude (allowing for Edge Forgiveness – discussed in more detail in the Parameters section) cannot amount to more than a 6-meter altitude gain). A downward slope of as much as -2° (-4% gradient) may also be regarded as flat terrain for a muscularly loaded activity.
4. Hills – This activity occurs when an individual increases their altitude during exercise/activity. The threshold criteria required to classify an activity under Hills can be a continuous rise over time that exceeds a 6 meter vertical gained from the flat, or a continuous slope of 2° or more (more or less) for more than 70 secs ('the more or less' in the above refers to our 'edge forgiveness' system that will allow some out of zone/threshold values if the data falls back within zone or threshold criteria within a short period of time).
5. Speed – i.e. running at 12 km/hr or more (for most people). One monitored parameter and threshold criterion used to identify a speed activity can be a stride rate of greater than 70 strides per minute. Alternatively, or in addition, an effort/intensity measure/parameter more closely associated with the user's own ability may be used to classify speed activities. The threshold criteria for such a parameter may be a user heart rate (HR) of more than 75% of their maximum heart rate, and/or of more than 80% of their Anaerobic Threshold (AT) HR. Effort may alternatively or in addition be measured using speed and/or power, in which case the threshold criteria for speed activities may be more than 90% of the individual's AT speed and/or more than 90% of their AT power respectively. In addition to any combination of the above parameters and their threshold criteria, a flat terrain criterion may be required by the classification system to identify a speed activity. In which case, the system may define a flat terrain for speed as an upward slope of less than 2° (or 4% gradient where consistent altitude (allowing for Edge Forgiveness – discussed in more detail in the Parameters section) cannot amount to more than a 6-meter altitude gain). A downward slope of as much as -2° (-4% gradient) may also be regarded as flat terrain for a speed activity.

Each of these could be referred to as a first activity, second activity or further activities.

There may be many different ways to classify an activity.

- 5 Other examples of Activity Types that can be measured along with the parameters used and the sensors used are listed. This is one embodiment of how the following Activity Types are described but by no means limits the type of parameter or sensor used. Smaller or greater parameter sets may be used to describe these Activity Types. Activity Events can be defined with a single Activity Condition or multiple Activity Conditions and
- 10 occurs over a shorter period of time than an Activity Type.

Sleep Measures:

Average Wake Up Time (7-day period) (Activity Event)

- 15
- Degree of Motion Accelerometer or 9 axis sensor
 - Postural Incline Accelerometer or 9 axis sensor
 - Time of Day Chronograph
 - Location GPS, Proximity sensors, Triangulation (cell phone towers)

Average Bed Time (7-day period) (Activity Event)

- 20
- Degree of Motion Accelerometer or 9 axis sensor
 - Postural Incline Accelerometer or 9 axis sensor
 - Time of Day Chronograph
 - Location GPS, Proximity sensors, Triangulation (cell phone towers)

Average Sleep Duration (7-day period) (Activity Type)

- 25
- Degree of Motion Accelerometer or 9 axis sensor
 - Postural Incline Accelerometer or 9 axis sensor
 - Time of Day Chronograph
 - Location GPS, Proximity sensors, Triangulation (cell phone towers)

Daily Activity (24 hours) (Activity and Activity Types)

- 30
- Degree of Motion Accelerometer or 9 axis sensor
 - Postural Incline Accelerometer or 9 axis sensor
 - Time of Day Chronograph
 - Location GPS, Proximity sensors, Triangulation (cell phone towers)
 - Upper Limb Motion Accelerometer or 9 axis sensor
 - Lower Limb Motion Accelerometer or 9 axis sensor

- 35 Number of Appointments (waking day 16+ hours) (Activity Event)

- Date
- Calendar Appointment Times

Average Work Arrival Time (7-day period) (Activity Event)

- Time of Day Chronograph
- Location GPS, Proximity sensors, Triangulation (cell phone towers)
- Travel Metrics GPS route, GPS speed

5 Average Home Arrival Time (7-day period) (Activity Event)

- Time of Day Chronograph
- Location GPS, Proximity sensors, Triangulation (cell phone towers)
- Travel Metrics GPS route, GPS speed

Number of Times out Late after Work (instances) (Activity Event)

- 10
- Time of Day Chronograph
 - Location GPS, Proximity sensors, Triangulation (cell phone towers)
 - Bed Time Parameters

Number of Consecutive Workouts (Activity Event)

- Recorded Activity Instances Activity Sensing Parameter/s
- 15
- Logged Dates for Activity Instances Calendar

Location of Peak Training Volume Week in Training Plan (Activity Event)

- Peak Training Volume ID Date Activity/Training Plan
- Current Date Calendar

Expected Workout Pattern (Activity Event)

- 20
- Microcycle Plan Activity/Training Plan
 - Recorded Activity Instances Activity Sensing Parameter/s
 - Logged Dates for Activity Instances Calendar

Workout Load (Activity and Activity Types)

- Recorded Activity Instance Activity Sensing Parameter/s
- 25
- Cumulative Power for a Workout Direct or Inferred Power

Workout Duration Compliance (Activity Types and Activity Events)

- Recorded Activity Instance Activity Sensing Parameter/s
- Cumulative Power for a Workout Direct or Inferred Power

Workout Resistance Activity Types Compliance (Activity Types and Activity Events)

- 30
- Planned Workout Activity Types Activity/Training Plan
 - Recorded Workout Activity Types Activity Type Sensing Parameter/s

Workout Speed Activity Types Compliance (Activity Types and Activity Events)

- Planned Workout Activity Types Activity/Training Plan
- Recorded Workout Activity Types Activity Type Sensing Parameter/s

Reps Lifted per Gym Equipment (Activity Types and Activity Events)		
	• Historic Reps Lifted	Reps Lifted History
	• Actual Reps Lifted (accelerometer)	Activity (Type) Sensing Parameter/s
5		consistent decelerations/accelerations)
	• Equipment ID	Unique Equipment ID
Rep Speed per Gym Equipment (Activity Types and Activity Events)		
	• Historic Reps Speed (out/back)	Rep speed History
	• Actual Rep Speed (accelerometer)	Activity (Type) Sensing Parameter/s
10		consistent decelerations/accelerations)
	• Equipment ID	Unique Equipment ID
Rep Resistance per Gym Equipment (Activity Types and Activity Events)		
	• Historic resistance lifted	Resistance (weight lifted) History
15	• Equipment ID	Unique Equipment ID
Rest between Sets per Gym Equipment (Activity Types and Activity Events)		
	• Set (Reps) completed	accelerometer or 9 axis sensor
	• New Set (Reps) started	accelerometer or 9 axis sensor
	• New Activity started	Equipment ID
20	• Time between Activities/Sets	Chronograph
Muscular and Cardiovascular Performance (Activity and Activity Types)		
	• Recorded Activity (Type) Instances	Activity Sensing Parameter/s
	• Work/Effort Parameter	Work/Effort Sensor
	• Response Parameter	Response Sensor
25	Heart Rate Variability (Activity Type)	
	• Heart Rate Variability (& derivations)	Heart rate
	• Time of Day	Chronograph
	• Location	GPS
	• Respiration Rate	Direct or Inferred
30	• Postural Incline	Accelerometer or 9 axis sensor
Location of Last Off Season (Activity Types and Activity Events)		
	• Logged Dates for Activity Instances	Calendar
	• Average durations Activity Instances	Time
	• Average workload of Activity	Power
35	• Current Date	Calendar

Each of these could be referred to as a first activity, second activity or further activities.

5. Inference Engine Examples:

a. Overview:

- 5 Figure 11 shows examples of different activity groupings that can be used for the Inference Engine. The sensors used are shown and the parameters they generate are also shown.

10 The metrics are obtained from the parameters and then applied to thresholds or zones to create an Observation Alert. Multiple Observation Alerts combine to create an Inference and an Inference Alert.

b. Inference Example One (Figure 12):

15 Figure 12 shows an example of the Inference Engine working. The Activity Groupings are shown. An Observation metric is obtained from an Activity, Activity Type or Activity Event metric comparison is applied to a threshold used to determine whether an Observation Alert occurs. If a match occurs with more than one type of Observation Alert that conforms to a pre-configured set of Observation Alerts that form a stored inference, then an Inference Alert is executed.

20

The Observations 1005 are:

Observation	Metric
When did Off Season Occur?	4 months ago
Expected Workout Pattern	Missed Tuesday and Thursday Planned Workouts
25 Workout Cumulative Watts	>800,000 watts
Average Waking Time for the week	5:00
Average Bed Time for the week	22:42
Average Deep Sleep Portion	3.2 hours
Average Sleep Length	5.3 hours
30 Heart Rate Variability	60

"When did Off Season occur?" could be determined through compliance measures of Activities or Activity Types or the system could ask the user the specific question using natural language processing or composing the question in text on a device.

35

Observation Comparison Thresholds:

Observation (1005)	Comparison Threshold (1010)	Observation Alert (1015)
4 months ago	Optimal = less than 3 months ago	Needs an Off Season

	Missed Tu & Th workouts	Microcycle Plan of expected workouts	Missing workouts
	> 800,000 watts in workout	>792,000 watts in workout	Effort too hard
	5:00 average for week	< 5:20average for week	Waking too early
	22:42 average for week	>22:30 average for week	Going to bed too late
5	3.2 hrs av deep sleep/week	< 3 hrs deep sleep	Low quality sleep
	5.3 hrs av sleep time/week	< 7.2hrs sleep duration	Not enough sleep
	60 av HRV RMSSD/week	< 30 av HRV RMSSD/week	Fatigue

8 Activities, Activity Types, Activity Events or Activity Conditions 1020 have created
 10 Observation Alerts which conform to the pre-configured set of Observation Alerts that
 make up the Inference Alert that might output the following advice;

15 Inference Alert: 'Need to take it a bit easier. Back Training off and focus on a better sleep
 pattern.' (1025)

The Inference Engine may also generate the following actions based on the Inference
 Alert:

- Adjust the Activity/Training Plan to provide an Off Season
- Re configure the plan so workouts are smaller on Tuesdays and Thursdays
- 20 • Reduce the workout workloads
- Set a waking alarm for later in the morning
- Have a text reminder that the user should go to bed earlier

c. Inference Example Two (Figure 13):

25 There are 4 observations in this example, the number of appointments in a work
 calendar, the average bed time, the average sleep length and a Heart Rate Variability
 measure.

The Observations 1100 are:

30	Observation	Metric
	Number of Calendar Appointments	7
	Average bed time/week	23:42
	Average sleep duration/week	6
	Average HRV RMSSD/week	60

35

Observation Comparison Thresholds:

Observation	Comparison Threshold	Observation Alert
-------------	----------------------	-------------------

7 appointments/tomorrow > 6 appointments Busy day tomorrow
 23:42 average bed time/week > 22:00 average bed time/week Bed time is too late
 6 hrs av sleep duration/week <7.2 hrs av sleep duration/week Not getting enough sleep
 60 av HRV RMSSD/week <30 av HRV RMSSD/week Fatigue detected

5

Four Activities, Activity Types, Activity Events or Activity Conditions have created Observation Alerts which conform to the pre-configured set of Observation Alerts that make up the Inference Alert that might output the following advice;

- 10 Inference Alert: 'Your sleep habits have been poor lately. You are tired and need to get to bed early as you have a busy day tomorrow.'

The Inference Engine may also generate the following actions based on the Inference Alert:

- 15
- Have a text reminder that the user should go to bed earlier
 - Cancel any Workouts in the Plan for tomorrow
 - Adjust the Training Plan for the rest of the week to be easier to promote recovery.

d. Inference Example Three (Figure 14):

- 20 In this example the Inference Engine is used to determine a user's load at work. It uses 5 Observation Alerts to determine this.

The Observations are:

Observation	Metric
25 Av Arrival Time at Work/week	7:00
Activity Load through day (steps)	18,000
Number of Appointments/day	8
Av Arrival Time at Home/week	19:23
Average HRV RMSSD/week	65

30

Observation Comparison Thresholds:

Observation	Comparison Threshold	Observation Alert
7:00 av arrival time work	> 7:45	Constant early work arrival
18,000 steps taken/day	> 5,000 steps	High Activity day
35 8 appointments set for day	> 6 appointments/day	High appointment load
19:23 av arrival time home	> 18:00 arrival time home	Constant late home
65 av HRV RMSSD/week	<30 av HRV RMSSD/week	Fatigue detected

The number of Observations Alerts is 5. These Observation Alerts match the pre-configured set of Observation Alerts that make up an Inference Alert. The following advice might be given;

- 5 Inference Alert: 'Your workload is very high and you might want to consider reducing this if it is consistent.'

The Inference Engine may also generate the following actions based on the Inference Alert:

- 10
- Set the wake up alarm later
 - Set a reminder 'go home' alarm
 - Reduce all exercise in the program for a period
 - Set a maximum appointment load in the calendar

- 15 e. Inference Example Four (Figure 15):

The Inference Engine uses 8 Observations to Infer fatigue and the issues related to it.

The Observations are:

Observation	Metric
20 Planned Microcycle pattern	missed Tuesday & Thursday workouts
Workout Plan Duration Compliance	60%
Workout Plan Resistance Activity Type Compliance	50%
Workout Plan Speed Activity Type Compliance	120%
Muscular Performance	80
25 Cardiovascular Performance	80
Average HRV RMSSD/week	60

Observation Comparison Thresholds:

Observation	Comparison Threshold	Observation Alert
missed Tu & Thu workouts	Microcycle Plan expected workouts	Missing workouts
60% Duration Compliance	< 80% compliance	Not enough duration
5 50% Resist Type Compliance	< 80% compliance	Not enough resistance
120% Speed Type Compliance	< 50% compliance	Too much speed
80 Muscular Performance	< 100 performance score	Performance deteriorating
80 Cardio Performance	< 100 performance score	Performance deteriorating
60 Av HRV RMSSD/week	<30 av HRV RMSSD/week	Fatigue detected

10

In this case the number of Observations Alerts is 8. An Inference Alert can be generated because there is a match between the pre-configured set of Observation Alerts that make up an Inference Alert. The following advice might be given;

- 15 Inference Alert: 'Your performance is dropping and your fatigue levels are increasing. You are also missing too many workouts. This is because you are doing too much speed training and not following the plan well.'

The Inference Engine may also generate the following actions based on the Inference

20 Alert:

- Reduce the amount of speed work in following workouts
- Increase the amount of easy duration training
- Reduce the volume of training for a week to promote recovery

25 f. Inference Example Four (Figure 16):

The Inference Engine uses 12 Observations to infer successful training.

The Observations are:

Observation	Metric
30 Planned Microcycle pattern	100% completed workouts
Gym Rep Number average/equipment	> + 1 rep/previous week
Gym Rep speed of lift/lower	1 rep/2sec
Gym Exercise Weight lifted	110% of average/previous week
Gym Exercise/Rep Rest periods	compliant with plan
35 Muscular Performance	110
Cardiovascular Performance	100
Average Waking Time/week	7:00
Average Bed time/week	22:30

Average deep sleep duration/week	3.2 hrs
Average total sleep duration/week	8.2 hrs
Average HRV RMSSD/week	78

5 Observation Comparison Thresholds:

	Observation	Comparison Threshold	Observation Alert
	Planned Microcycle pattern	% compliance to plan	following plan well
	Rep Number av/equipment	av reps number/last 3 workouts	rep number is increasing
	Gym Rep speed of lift/lower	rep speed (s)/last 3 workouts	rep speed is consistent
10	Gym Exercise Weight lifted	% difference to last 3 workouts	weight is increasing
	Gym Exercise/Rep Rest periods	% diff from planned rest	rest periods are optimal
	Muscular Performance	% difference to last 3 workouts	strength increasing
	Cardiovascular Performance	% difference to last 3 workouts	fitness static
	Average Waking Time/week	<5:20	waking time is good
15	Average Bed time/week	> 22:30	bed time is optimal
	Average deep sleep time/week	<3 hrs	deep sleep is good
	Average total sleep time/week	> 7.2 hrs	sleep duration good
	Average HRV RMSSD/week	< 30	no fatigue present

- 20 The number of Observations Alerts is 12. An Inference Alert can be generated because there is a match between the pre-configured set of Observation Alerts that make up an Inference Alert. The following advice might be given;

- 25 Inference Alert: 'Excellent work. You are managing recuperation well, your gym training is being completed thoroughly and you are getting performance rewards for this.'

The Inference Engine may also generate the following actions based on the Inference Alert:

- 30 • Increase to training load slightly

g. Inference Example Four (Figure 17):

The Inference Engine uses 11 Observations to infer long term low grade fatigue.

The Observations are:

35	Observation	Metric
	Last Off Season occurrence	5 months ago
	Cumulative watts in a workout	792,200 watts
	Workout Plan Duration Compliance	100%

	Workout Plan Activity Type Compliance	100%
	Workout Plan Resistance Activity Type Compliance	100%
	Workout Plan Speed Activity Type Compliance	100%
	Gym Rep Number average/equipment	same as previous week
5	Gym Exercise Weight lifted	same as previous week
	Muscular Performance	90
	Cardiovascular Performance	88
	Average HRV RMSSD/week	67
10	Observation Comparison Thresholds:	
	Observation	Comparison Threshold
	Observation Alert	
	Last Off Season occurrence	< 3 months
	Cumulative watts in a workout	>792,000 watts
	Workout Plan Time	< 80%
15	Workout Plan Activity Type	<80%
	Resist Activity Type	<80%
	Speed Activity Type	<80%
	Gym Rep number average	same/last 3 workouts
	Gym Exercise Weight lifted	same/last 3 workouts
20	Muscular Performance	< 100
	Cardiovascular Performance	<100
	Average HRV RMSSD/week	<30
		needs an off season
		workout load good
		good compliance
		good compliance
		good compliance
		not improving
		not improving
		not improving
		fatigue indicated

25 The number of Observations Alerts is 11. An Inference Alert can be generated because there is a match between the pre-configured set of Observation Alerts that make up an Inference Alert. The following advice might be given;

30 Inference Alert: 'You are training well but you need some long term rest which is known as an off season. Improvements will not happen until you have recovered from the accumulated training load of the last few months.'

The Inference Engine may also generate the following actions based on the Inference Alert:

- Change the program to an off season
- Re configure future training plans

h. Inference Example Four (Figure 18):

The Inference Engine uses 6 Observations to infer long term low grade fatigue.

The Observations are:

Observation	Metric
Gym Rep Number average/equipment	0 rep increase/previous week
5 Gym Rep speed of lift/lower	1 rep/3sec slower
Gym Exercise Weight lifted	100% of average/previous week
Gym Exercise/Rep Rest periods	115%
Muscular Performance	96
Cardiovascular Performance	100

10

Observation Comparison Thresholds:

Observation	Comparison Threshold	Observation Alert
Gym Rep Number average	> 100%/previous week	no improvement
Gym Rep speed of lift/lower	1 rep/2sec	slower lift speed
15 Gym Exercise Weight lifted	> 100%/previous week	no weight increase
Gym Rep Rest periods	>120%/average	rest period longer
Muscular Performance	<100	reduced
Cardiovascular Performance	<100	static

20 The number of Observations Alerts is 6. An Inference Alert can be generated because there is a match between the pre-configured set of Observation Alerts that make up an Inference Alert. The following advice might be given;

Inference Alert: 'You are muscularly tired. Let's have a rest from gym work tomorrow.

25 We need to rest up to start improving again.'

The Inference Engine may also generate the following actions based on the Inference Alert:

- Gym workout for tomorrow cancelled
- 30 • Gym workloads reduced for the rest of the week
- Running & Cycling resistance training (hill training) reduced for rest of week

Other examples where combined observation alerts provide an inference alert that infers that the user is exercising too hard (Figure 19), or consistently exercising too much just before a key milestone date in their training (figure 20) or that the user is too inactive
35 and needs to exercise more. (figure 21)

6. Sensor Descriptions:

a. Sensor Overview

The system is able to be configured to many different types of sensors specialised at
 5 detecting different parameters that can be combined to contextualise different Activities,
 Activity Types and Activity Events. The main forms of sensor are:

- Worn sensors
- Internet Data based on remote sensors

10 Worn Sensors:

Worn sensors are sensors worn by the user in various device form factors. These form
 factors could be a mobile phone, specialised device, a device located on the wrist, device
 worn on the head as smart glasses or a helmet or a device worn on the hip, upper arm or
 other parts of the body.

15 Worn sensors include:

- GPS
- Heart Rate receiver and transmitter (or Optical – PPG)
- Accelerometer
- Barometer
- 20 • Magnetometer
- Gyroscope
- Thermometer
- Agrometer

Other sensors could include:

- 25 • Magnet based sensor (e.g. cycling speed sensor, rowing stroke rate sensor)
- Remote weather data

b. GPS Sensor:

A GPS sensor can be used for determining the following parameters:

30 Speed

Location

Distance

Altitude

GPS sensors can be found on many devices currently, being smart phones, sports
 35 watches, smart watches, smart glasses, smart garments and device chest straps and
 bras and other devices housed in sports equipment.

Examples of smart phones include the iPhone and Samsung S4. GPS sensors are also embedded in sports watches like the Suunto Ambit, Fitbit Surge and Polar V800.

New smart watches like the Samsung Gear S now have a GPS sensor contained on the wrist of a smart watch. Reccon instruments makes sports sunglasses that contain a GPS sensor. The Zephyr Bioharness 3 is a chest mounted strap with multiple sensors including a GPS sensor.

Each is able to track speed location and distance based on utilising GPS satellites in the sky above triangulating a user's position.

Speed:

GPS determines speed by measuring a user's location and then measuring the users location at a different time and calculating the distance and time taken to travel the distance between. This allows a GPS which usually updates every second to calculate speed.

Location:

GPS sensors use satellites to triangulate location and provide a latitude and a longitude.

Distance:

The GPS sensor can determine distance by calculating the location of a user and then determine the users location at a later point in time which allows a distance to be inferred from the two location points. GPS sensors usually do this once a second and accrue the cumulative distance as a runner runs or a cyclist cycles.

Altitude:

GPS can determine altitude in two ways. One is to triangulate the altitude of the user but this is often relatively inaccurate due to the overhead location of the satellites. Another way is to use a Digital Elevation Model.

A digital elevation model (DEM) is a digital representation of ground surface topography or terrain. Various data sets are available of differing accuracy levels based on satellite surveys of the earth including the Shuttle Radar Topography mission in 2000. Once the coordinates of a user are known their position can be overlaid onto the topography of their location in real time or in post processing. Digital Elevation Models (sometimes known as Digital Terrain Models) are used for post processing of data by companies like Bones in Motion and Sportsdo. A DEM can be used with any GPS compliant device like a mobile phone and altitude can be determined from GPS as in the Garmin devices. Some of Garmin's older model sports devices use GPS in its Forerunner 205, 305 and 405 series devices to show altitude. GPS altitude is obtained by the triangulation of satellites in the sky overhead at the time.

c. Heart Rate Sensor

The heart rate sensor can detect:

- Heart rate
- Heart Rate Variability (in some cases)
- 5 • Inferred Respiration Rate (in some cases)

Heart Rate:

Heart rate can be measured directly currently through a strap that contains 2 electrodes that is placed across the chest and was originally designed by Polar Electro which filed its patent in 1979 and is the world leader in wireless chest strap heart rate monitors. The
 10 patent has now expired and many other companies use this technology including Timex, Suunto, Garmin, Cardiosport, Impulse and Zephyr.

There are now many Heart Rate Monitor straps like the Zephyr HRM BT and the Mobimotion Spurty chest strap that do not have a data receiver but rather Bluetooth data
 15 to devices like a mobile phone. Still other devices like the SMHeartLink act as a bluetooth receiver for the Apple iPhone to accept heart rate data from a heart rate strap and the FRWD B series devices that are able to receive broadcast heart rate data from most wireless heart rate straps and resend the data to a phone via Bluetooth. Other devices receive broadcast data using the ANT+ signal.

20 Heart rate is becoming wide available as two primary kinds of sensors. These are chest based sensors that pick up the electrical activity of the heart and optical sensors or photoethysmogram sensors. The more traditional sensors using electrical signal detection include the Polar heart rate monitor range, the Suunto sports watch range and
 25 many others. Optical sensors are housed in the Mio Alpha and Link, Wellograph, Micoach Smart Run, the Samsung Gear S, the Basis Peak and the Apple Watch. Each device can detect heart rate although some devices can currently only detect heart rate when a user is sedentary as opposed to exercising.

30 Heart rate is not just limited to humans. Heart rate has been measured for horses for over 15 years using various Polar Equine Heart Rate monitors like the Polar Equine RS800CX G3 or the CS600X for trotting.

Heart Rate Variability:

35 HRV (Heart Rate Variability) can be used to measure the cardioneuro status of the body. Heart rate variability measures the average of the time (in ms) between a series of heart beats with poor cardioneuro status representing a high degree of uniformity in the time between heart beats and a good cardioneuro status being where there is high variability

in the time between heart beats. FRWD, Suunto, Wellograph and Polar devices are able to measure heart rate variability.

5 Recently there has been a proliferation of HRV apps for mobile phones pairing with heart rate sensors to measure cardioneuro status. These include ithlete, Bioforce and HRV for Training.

Various derivations of HRV including SD1, the log of RMSSD to name several are becoming accepted as methods of measuring cardioneuro status.

10

Inferred Respiration Rate:

Respiration rate is calculated by measuring expansion of the chest using a chest strap as used in the Zephyr Bioharness or OMSignal smart shirt.

15 Firstbeat have licensed a heart rate measurement system to Suunto and FRWD that derives respiration rate and ventilation (which could also be used to measure intensity) through heart rate which increases during inhalation and decreases on exhalation indicating breaths per minute. The strength of the electrical signal of the QRS part of the ECG waveform can be used to infer respiration rate.

20

d. Accelerometer Sensor

Accelerometers are very widely functional in what they can measure:

- Degree of Motion (sleep & activity assessment)
- Footfall and Footfall Rate
- 25 • Speed of a runner or walker
- Cycle Speed and Cadence

Multi and single axis Accelerometers have become very prevalent in devices in the market. They are housed in most smart phones, in bracelet type activity tracking devices and smart watches and sports watches and other measuring devices.

30

Degree of Motion, Footfall and Footfall Rate

Iphones and most higher end Samsung phones contain accelerometers as do fitness trackers like Fitbit and Jawbone activity trackers. Smart watches like the Apple watch and Samsung Gearfit contain accelerometers.

35

The sports watch Garmin 910 contains an accelerometer as do Garmin cycle speed and cycle cadence measuring sensors. Other measuring devices that contain accelerometers include chest straps like the Zephyr Bioharness 3.

The Polar FA20 activity tracker for example can also be used to determine calories burned. There are 2 wrist devices built by Adidas and Nike known as the micoach Zone and the Nike Sportband which also contain accelerometers. Other Activity Trackers
5 include Actiped, Directlife, Bodymedia's Fit system, Mytrak's M2 and Polar's FA20.

Accelerometers can be used to determine motion with high amounts of motion being inferred as more activity and low amounts of motion being inferred as less activity. Limb movement can be determined either together or independently and steps and limb
10 turnover rates (e.g. stride rate) can be determined by measuring impacts characterised by decelerations and accelerations.

Sleep can be tracked where the accelerometer is placed in the bed next to the user and the accelerometer infers awake as being high movement, light sleep as low movement
15 but some movement and deep sleep and very little movement.

Stride Rate

This involves the use of an accelerometer that records the repetitive impact for each stride which is then summed over 1 minute of time providing a measure of strides per
20 minute. Stride rate is a handy extra measure as it can be used to determine the speed of leg movement which further contributes to building a picture of what the user is doing. A stride rate of 55 strides per minute indicates that the user is walking, 80 strides per minute is easy running, and 90 strides per minute would be fast running for example. The Polar RS800 measures and displays stride rate in real time and most smart phones
25 contain accelerometers these days which can be used to measure stride rates on a phone by counting impacts over time.

Cycle Speed and Cadence

Garmin have created innovative bike speed sensors that appear to use an accelerometer
30 to determine rotation of the wheel which can be used to determine speed if the circumference of the wheel is known. Cycle Cadence can also be determined in the same way.

35 e. Inclinometer

An accelerometer can be used as an inclinometer where the postural incline of a user can be determined by an accelerometer fixed to the body. Lying down can be differentiated for standing and using two accelerometers attached to the waist and thigh can determine

whether a user is standing or sitting. 100 – General Activity. Accelerometers can be attached to many parts of the body other with a number of other sensors like a gyroscope and a magnetometer and specific limb actions can be trained to develop an activity model for detection. In this case the accelerometer is taught that a series of
5 accelerations and decelerations represent a specific action which can then be detected if that particular activity is elicited by the user. Smart garments like hexoskin and OMSignal hold great promise in this area.

Suunto and some cycle computer companies include inclinometers on their devices to
10 measure slope/gradient change for a cyclist. The Sigma Rox 8.0 uses an inclinometer as well as a barometer to measure slope or gradient.

Exercise machines that can simulate altitude change (going up or down a hill) in various mechanical ways (like using a predetermined incline) for determining gradient or slope in
15 equipment like treadmills

Treadmill manufacturers can preset inclines on their treadmills and program them to show various inclines based on an inbuilt program or through manual adjustment by the
20 user.

Simulated Incline Using Resistance:

There are various cycle ergometers which use various systems to create the equivalent of altitude change. These can be complete bike ergometers or machines that a bike is placed into. The cycle simulator manufacturers can program their devices to increase
25 resistance to simulate gradient or slope through mechanical braking (e.g. Monarch and Cateye CS1000) or electronic braking (e.g. Tracx and Computrainer) and can also use real incline change.

f. Barometer

30 Barometers detect minute changes in air pressure and therefore can not only be used to measure changes in weather as changes in altitude create the same measureable situations. Altitude change can be measured in many different ways through special purpose sensor devices.

35 Altitude change is a way in which a sensor can determine the terrain the user is on. For example, an increase in altitude or gradient indicates that the user is moving uphill, a decrease in vertical meters or a decline means the user is going downhill and no altitude change or a flat gradient or slope means the user is on the flat. Many devices currently

contain digital barometers and thermometers. Examples include Suunto sports watches (e.g. Suunto X6 & T6), the Timex Altitude Barometer Adventure Tech watch, the Casio Pathfinder series of watches and Polar Heart Rate devices (e.g. RS800, CS600 etc).

- Garmin also have devices like the Garmin 910 and Fenix sports watches which contain a
 5 barometer for altitude. Devices that contain a barometer or GPS can all determine altitude change like the Suunto and Polar Products. Devices like the Sigma BC 2209 MHR and Garmin Edge 705 contain a barometer for altitude measure.

g. Thermometer and Hygrometer

- 10 A thermometer can be used to measure the ambient temperature the user currently experiences. Digital thermometers are now present in mobile phones like the Samsung S4 as are hygrometers that measure humidity levels. Thermometers are also present in smart watches like the Samsung Gear S and in sports watches like the Polar 625x. The
 15 Recon Jet smart eyewear contains a temperature sensor.

h. Magnet based sensor (e.g. cycling speed sensor, rowing stroke rate sensor)

- There are many magnet based sensors where a magnet passes a sensor at regular intervals to measure a speed or rate of movement. For example, if a magnet is mounted to the wheel of a bike and a sensor is mounted on the forks then the magnet will pass
 20 the sensor once every pedal rotation and if the circumference of the wheel is known and time is known then speed can be calculated. The same concept applies to a cycle cadence sensor or rowing stroke rate sensor where the number of magnet passes of a pedal or rowers seat on a slide are recorded per minute to provide a pedal cadence or stroke rate metric. Cateye and Coxbox have employed this system in their devices for many years.
 25 Most bike computers use a magnet on the spokes like the Polar CS300. Stroke rate is usually measured in rowing based on a magnet being attached to and under the rowers moving seat and a sensor is placed in the boat directly below the seat. A stroke is sensed every 2nd time the magnet passes over the sensor. This count is then measured versus one minute which provides the ability to measure strokes per minute. Strokes per minute
 30 can be measured more directly at the rigger, by force sensors in the blade of the oar, or by the increase in boat oscillation speed, or be change in force measured by an accelerometer as the rower takes a stroke.

- Similar methods can be applied to Swimming as evidenced by the Speedo Strokz Stroke
 35 Counter that was available in the late 1990's.

The seat magnet and sensor is commonplace in rowing and there is now new Surge Rate technology incorporating a 3 axis accelerometer to measure the change in force that

denotes a kayaker or rower's stroke, thereby allowing stroke rate to be determined when combined with time as in Nielsen Kellerman Rowing and Kayaking devices like the Stroke Coach, Cox Box and Speed Coach.

5 Stroke Rate can also be mechanically measured in indoor rowing machines such as a Concept 2 rowing ergometer, by measuring a change in power or speed in the fan used for resistance, by a change in prescription of the chain/cable attached to the rowing handle, or by using the magnet and sensor under the rower's seat.

10 It may also be possible to fix an accelerometer to a kayaker's paddle shaft to measure the oscillation in the blade entering the water on the left and right sides of the boat.

Cadence or Distance per Pedal Stroke:

15 Cadence is a useful extra measure which usually involves a magnet on the pedal arm (crank) passing a sensor on the chain stay of the bike. This can indicate one pedal revolution and when used in conjunction with time creates a pedal cadence measure in revolutions per minute. Distance per pedal stroke is another very useful measure that can be calculated by knowing the gear that the rider is in (e.g. Shimano Flight Deck) or by knowing the distance travelled in a pedal revolution which involves a cadence
20 measure and a distance measure (which is based on the speed measure).

i. Remote Data

Remote weather data can be accessed over the internet and used to forecast weather conditions for a bike ride, walk, run or drive. Weather inputs could be temperature, heat
25 index, wind speed, visibility, rainfall or snowfall forecast. Other remote data could include traffic conditions and notifications on whether dry cleaning is ready to be picked or what appointments a user has on today. This is available in systems like Google Now and the Apple iPhone Calendar app.

30 j. Respiration

Respiration can be inferred through heart rate as previously shown or a chest strap or smart garment can measure inhalations and exhalations through expansion and contraction of the garment or strap. Devices that include this are the Hexoskin, OMsignal and Zephyr Bioharness 3.

35

k. Proximity/Ambient Light

In the case of military, fire and rescue services, the system could switch from outdoor location to indoor location detection. Crude speed measures could utilise infrared, ultrasonic, RFID, UWB and signal strength systems. Many smartphones like the iPhone have an ambient light sensor. This can be used to detect light levels for phone screen brightness and to turn the screen off as a user brings the phone to their ear. This sensor can provide information on the light levels that the user is in including night and potentially brighter or cloudier days.

l. Blood Pressure

Blood pressure is not currently available in lightweight wearable devices. There are blood pressure halters that have been used by the medical profession for many years but these are cumbersome and bulky. There are devices that may soon be able to infer blood pressure from heart rate signals like heart rate variability and optical sensors.

m. Electrocardiograph (ECG)

Polar heart rate monitors put out an inferred ECG device many years ago but unfortunately there was little commercial interest at the time. There are ECG halters that are currently available but these are bulky. Very soon real time ECG measures in lightweight wearable devices will be available.

n. Electromyography

Electromyography is a direct way of measuring muscle movement by measuring the electrical activity of the muscles. The strength of a muscular contraction, how long it is sustained for and the degree of relaxation are all potentially measureable. There are several systems being worked on at the moment including Titan Arm, Leo Fitness Intelligence and Athos.

o. Magnetometer and Gyroscope

Team sports are starting to take sport sensing more seriously. Catapult sports and the Adidas Micoach Teams Sports use magnetometers and gyroscopes which way the user is facing and therefore the user's movement (i.e. backwards, lateral etc). A magnetometer measures the direction of the magnetic field at a point in space and a gyroscope measures orientation. Because of this they can be used to determine direction, orientation and possibly incline. This is currently being used to study foot biomechanics with devices like IMeasureU which is an integrated accelerometer, magnetometer and gyroscopic device. User motion detection has become quite common using 9 axis sensors. These sensors are a combination of 3 sensors being 3 axes each for an

Accelerometer, Gyroscope and Magnetometer. There are devices such as the Atlas fitness tracker, Lumo, or Moov. In each case these devices can ascertain movement of a limb in 3D to some extent.

5 p. Power:

Power is usually a direct measure in cycling. Power measurement for cycling was pioneered by SRM who use strain gauges attached to the large front sprockets (chain rings) at the bottom bracket attached to the pedal cranks. PowerTap use a system originally used in the Look Max One where the power is measured in the hub of the rear
10 wheel. Ergomo use power measured from the bottom bracket directly.

There have been several indirect measurements of power most notably being the Polar system (e.g. 625X or 725 products) which measures the strain on the chain as the cyclist is riding. Other cycle computers indirectly compute power by measuring a combination of
15 speed, weight and slope or gradient.

An indirect way of assessing power is present in the Shimano Flight Deck and in the Australian Institute of Sport system which measures the gear that the rider is in allowing a calculation of distance per pedal stroke. In each case the gear that the rider is in, is
20 known and the distance for each gear for a pedal turn is fixed.

Power for a walker or runner currently can only be inferred by applying a Power algorithm to the data based on speed, the user's weight and the slope or gradient at the time. It may not be too long before power will be more directly measured using force
25 plates in shoes or by converting acceleration data in a shoe to power.

Crude power measures may be able to be inferred from the above mentioned indoor location detection systems.

30

Multi sensor:

The system is not bound to a specific device but rather may use many different types of special purpose devices so long as they contain the required sensors and provide the right parameters. It may occur also that the system utilizes data from sensors from
35 several different devices as is the case with using a smart phone with internal GPS and heart rate data from a Zephyr HRM BT or the barometric, temperature, GPS and heart rate data from a FRWD B series device combined with the internal accelerometer found in a smart phone.

Devices such as BodyMedia's fit system device and the Mytrak M2 are portable weight loss recreational fitness devices. There are devices like the Mobimotion Spurty chest strap that contains both a heart rate monitor and GPS that Bluetooth data to a phone and many other devices that accept and log Bluetooth data such as the FRWD W and B series.

Other Sensors:

In the case of military, fire and rescue services, the system could switch from outdoor location to indoor location detection. Crude speed measures could utilise infrared, ultrasonic, RFID, UWB and signal strength systems.

Impeller:

Speed can be measured via GPS or an impeller to measure speed through the water. Speed can be measured for an indoor rowing ergometer by the braking pressure for braked devices or by the speed at which the fan spins at.

Impellers are used in Nielsen Kellerman products like the Stroke Coach, Cox Box and Speed Coach for rowing. The Garmin Forerunner series are often used by kayakers which utilize GPS.

Pressure sensors:

Companies like Sensoria use pressure sensors to establish footstrike patterns in shoes combined with an accelerometer.

SYSTEM REQUIREMENTS

It will be appreciated that the system of the invention may be implemented on any suitable hardware system, platform or architecture. The hardware system may be provided on-board a device used by the user or on a remote server for example, and preferably comprises at least a processor for running the classification system and in particular the algorithms, at least one memory component for storing at least the algorithms and the threshold criteria, and interface circuitry for communicating with external components that either directly or indirectly provide sensor output data. It will be appreciated that the processor may be any form of programmable hardware device, whether a CPU, Digital Signal Processor, Field-Programmable Gate Array, Microcontroller, Application-Specific Integrated Circuit, or the like.

There are 3 possible configurations for housing the classification system.

- The data is processed 'on board' a measurement device (i.e. the classification system is within the measurement/monitoring device),
 - Data is processed via manual (controlled by user) or automatic transfer (upload and download) of data via a communications network (e.g. telecommunications, 5 wifi etc) to a remote server that contains the classification system,
 - or manual or automatic transfer of data to a home computer that either contains the system or that transfers (upload and download) the data to a remote server that contains the system.
- 10 They system may house the infrastructure for the classification and allow a person, trainer or coach to input the one or more parameters and/or the one or more associated thresholds that define an activity.

15 The invention is also intended to cover a method of analysing an exercise session as employed by the system described above.

The foregoing description of the invention includes preferred forms thereof. Modifications may be made thereto without departing from the scope of the invention.

CLAIMS

1. A method of classifying a plurality of activities associated to a user, the method
5 comprising:
receiving first activity data indicative of a first activity performed by the user
during a first time interval, the first activity data comprising a plurality of measurements
associated to at least one first parameter monitored during the first activity;
receiving second activity data indicative of a second activity performed by the
10 user during a second time interval, the second activity data comprising a plurality of
measurements associated to at least one second parameter monitored during the second
activity, the second activity different to the first activity;
a processor comparing at least some of the first activity data and at least some of
the second activity data with respective sets of measurements stored on a tangible
15 computer readable medium;
a processor generating a set of observation alerts based at least partly on the
comparison of the first activity data and the second activity data with the respective sets
of measurements;
a processor comparing the set of observation alerts with respective sets of
20 observation alerts stored on a tangible computer readable medium; and
on detecting a match between the set of observation alerts and at least one set of
the stored observation alerts, a processor generating at least one inference alert.
2. The method as claimed in claim 1 wherein observation alerts are based on
25 comparisons of measured parameters against thresholds.
3. The method as claimed in claim 2 wherein observation alerts are generated when
one or both of the first activity data and the second activity data exceeds a threshold, is
less than a threshold, or lies within a range.
30
4. The method as claimed in any one of the preceding claims wherein inference
alerts are based on comparisons of a set of observation alerts with a plurality of stored
sets of observation alerts.
- 35 5. The method as claimed in any one of the preceding claims wherein different
activity comprises different muscle activity.
6. The method as claimed in any one of claims 1 to 4 wherein different activity
comprises different postural behaviour.
40

7. The method as claimed in any one of the preceding claims wherein the first activity and/or the second activity is selected from sleep/bedtime, biomedical, work, CV, gym, behaviour, performance, environmental and neurocardio.
- 5 8. The method as claimed in claim 7 wherein sleep/bedtime activity is measured by at least one parameter selected from sleep duration, deep sleep, rem sleep, light sleep, bed time, wake time, time, date.
9. The method as claimed in claim 7 wherein biomedical activity is measured by at
10 least one parameter selected from Electrocardiograph data, Blood Pressure, time, date.
10. The method as claimed in claim 7 wherein work activity is measured by at least one parameter selected from steps, posture, active motion, inactivity, time, date, calendar, and appointments.
- 15 11. The method as claimed in claim 7 wherein CV activity is measured by at least one parameter selected from activity type data, activity type compliance, speed compliance, easy compliance, resistance compliance, time and date.
- 20 12. The method as claimed in claim 7 wherein gym activity is measured by at least one parameter selected from activity type data, activity type compliance, per exercise = rep compliance, rep speed compliance, rest compliance, weight compliance, time, date.
13. The method as claimed in claim 7 wherein behaviour activity is measured by at
25 least one parameter selected from off season, number of workouts completed vs time, workout pattern, big weeks, taper weeks, race week, pace, SR, leave home time, work arrival time, leave for home time, arrive home time, time, date.
14. The method as claimed in claim 7 wherein performance activity is measured by at
30 least one parameter selected from cardio performance, muscular performance, overall performance, time, date.
15. The method as claimed in claim 7 wherein environmental activity is measured by
35 at least one parameter selected from temperature, weather forecast, humidity, altitude, terrain.
16. The method as claimed in claim 7 wherein neurocardio activity is measured by at least one parameter selected from posture, respiration, inactive time, heart rate variability, time, date.

17. The method as claimed in any one of the preceding claims wherein the first activity data comprises a plurality of measurements associated to a first set of parameters monitored during the first activity.

5

18. The method as claimed in any one of the preceding claims wherein the second activity data comprises a plurality of measurements associated to a second set of parameters monitored during the second activity.

10 19. The method as claimed in any one of the preceding claims wherein comparing the at least some of the first activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the at least some of the first activity data with measurements associated to the at least one parameter monitored during the first activity.

15

20. The method as claimed in any one of the preceding claims wherein comparing the at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the at least some of the second activity data with measurements associated to the at least one parameter
20 monitored during the second activity.

21. The method as claimed in any one of the preceding claims wherein the second time interval is different to the first time interval.

25 22. The method as claimed in any one of claims 1 to 20 wherein the second time interval overlaps the first time interval.

23. A system configured to classify a plurality of activities associated to a user, the system comprising:

30

at least one computer-readable medium; and

at least one processor, the at least one processor programmed to:

receive first activity data indicative of a first activity performed by the user during a first time interval, the first activity data comprising a plurality of measurements associated to at least one first parameter monitored during the first activity;

35

receive second activity data indicative of a second activity performed by the user during a second time interval, the second activity data comprising a plurality of measurements associated to at least one second parameter monitored during the second activity, the second activity different to the first activity;

compare at least some of the first activity data and at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium;

5 generate a set of observation alerts based at least partly on the comparison of the first activity data and the second activity data with the respective sets of measurements;

compare the set of observation alerts with respective sets of observation alerts stored on the at least one computer-readable medium; and

10 on detecting a match between the set of observation alerts and at least one set of the stored observation alerts, generate at least one inference alert.

24. The system of claim 23 wherein observation alerts are based on comparisons of measured parameters against thresholds.

15 25. The system of claim 24 wherein observation alerts are generated when one or both of the first activity data and the second activity data exceeds a threshold, is less than a threshold, or lies within a range.

20 26. The system of any one of claims 23 to 25 wherein inference alerts are based on comparisons of a set of observation alerts with a plurality of stored sets of observation alerts.

25 27. The system of any one of claims 23 to 26 wherein different activity comprises different muscle activity.

28. The system of any one of claims 23 to 26 wherein different activity comprises different postural behaviour.

30 29. The system of any one of claims 23 to 28 wherein the first activity and/or the second activity is selected from sleep/bedtime, biomedical, work, CV, gym, behaviour, performance, environmental and neurocardio.

35 30. The system of claim 29 wherein sleep/bedtime activity is measured by at least one parameter selected from sleep duration, deep sleep, rem sleep, light sleep, bed time, wake time, time, date.

31. The system of claim 29 wherein biomedical activity is measured by at least one parameter selected from Electrocardiograph data, Blood Pressure, time, date.

32. The system of claim 29 wherein work activity is measured by at least one parameter selected from steps, posture, active motion, inactivity, time, date, calendar, and appointments.
- 5 33. The system of claim 29 wherein CV activity is measured by at least one parameter selected from activity type data, activity type compliance, speed compliance, easy compliance, resistance compliance, time and date.
34. The system of claim 29 wherein gym activity is measured by at least one
10 parameter selected from activity type data, activity type compliance, per exercise = rep compliance, rep speed compliance, rest compliance, weight compliance, time, date.
35. The system of claim 29 wherein behaviour activity is measured by at least one
15 parameter selected from off season, number of workouts completed vs time, workout pattern, big weeks, taper weeks, race week, pace, SR, leave home time, work arrival time, leave for home time, arrive home time, time, date.
36. The system of claim 29 wherein performance activity is measured by at least one
20 parameter selected from cardio performance, muscular performance, overall performance, time, date.
37. The system of claim 29 wherein environmental activity is measured by at least one parameter selected from temperature, weather forecast, humidity, altitude, terrain.
- 25 38. The system of claim 29 wherein neurocardio activity is measured by at least one parameter selected from posture, respiration, inactive time, heart rate variability, time, date.
39. The system of any one of claims 23 to 38 wherein the first activity data comprises
30 a plurality of measurements associated to a first set of parameters monitored during the first activity.
40. The system of any one of claims 23 to 39 wherein the second activity data
35 comprises a plurality of measurements associated to a second set of parameters monitored during the second activity.
41. The system of any one of claims 23 to 40 wherein comparing the at least some of the first activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the at least some of the first activity

data with measurements associated to the at least one parameter monitored during the first activity.

42. The system of any one of claims 23 to 41 wherein comparing the at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the at least some of the second activity data with measurements associated to the at least one parameter monitored during the second activity.

43. The system of any one of claims 23 to 42 wherein the second time interval is different to the first time interval.

44. The system of any one of claims 23 to 42 wherein the second time interval overlaps the first time interval.

45. A computer-readable medium having stored thereon computer-executable instructions that, when executed by at least one processor, cause the at least one processor to perform a method of classifying a plurality of activities associated to a user, the method comprising:

receiving first activity data indicative of a first activity performed by the user during a first time interval, the first activity data comprising a plurality of measurements associated to at least one first parameter monitored during the first activity;

receiving second activity data indicative of a second activity performed by the user during a second time interval, the second activity data comprising a plurality of measurements associated to at least one second parameter monitored during the second activity, the second activity different to the first activity;

comparing at least some of the first activity data and at least some of the second activity data with respective sets of measurements stored on a tangible computer readable medium;

generating a set of observation alerts based at least partly on the comparison of the first activity data and the second activity data with the respective sets of measurements;

comparing the set of observation alerts with respective sets of observation alerts stored on the at least one computer-readable medium; and

on detecting a match between the set of observation alerts and at least one set of the stored observation alerts, generating at least one inference alert.

46. The computer-readable medium as claimed in claim 45 wherein observation alerts are based on comparisons of measured parameters against thresholds.

47. The computer-readable medium as claimed in claim 46 wherein observation alerts are generated when one or both of the first activity data and the second activity data exceeds a threshold, is less than a threshold, or lies within a range.
- 5
48. The computer-readable medium as claimed in any one of claims 45 to 47 wherein inference alerts are based on comparisons of a set of observation alerts with a plurality of stored sets of observation alerts.
- 10
49. The computer-readable medium as claimed in any one of claims 45 to 48 wherein different activity comprises different muscle activity.
50. The computer-readable medium as claimed in any one of claims 45 to 48 wherein Preferably different activity comprises different postural behaviour.
- 15
51. The computer-readable medium as claimed in any one of claims 45 to 50 wherein Preferably the first activity and/or the second activity is selected from sleep/bedtime, biomedical, work, CV, gym, behaviour, performance, environmental and neurocardio.
- 20
52. The computer-readable medium as claimed in claim 51 wherein sleep/bedtime activity is measured by at least one parameter selected from sleep duration, deep sleep, rem sleep, light sleep, bed time, wake time, time, date.
53. The computer-readable medium as claimed in claim 51 wherein biomedical
- 25
- activity is measured by at least one parameter selected from Electrocardiograph data, Blood Pressure, time, date.
54. The computer-readable medium as claimed in claim 51 wherein work activity is measured by at least one parameter selected from steps, posture, active motion,
- 30
- inactivity, time, date, calendar, and appointments.
55. The computer-readable medium as claimed in claim 51 wherein CV activity is measured by at least one parameter selected from activity type data, activity type compliance, speed compliance, easy compliance, resistance compliance, time and date.
- 35
56. The computer-readable medium as claimed in claim 51 wherein gym activity is measured by at least one parameter selected from activity type data, activity type compliance, per exercise = rep compliance, rep speed compliance, rest compliance, weight compliance, time, date.

57. The computer-readable medium as claimed in claim 51 wherein behaviour activity is measured by at least one parameter selected from off season, number of workouts completed vs time, workout pattern, big weeks, taper weeks, race week, pace, SR, leave
5 home time, work arrival time, leave for home time, arrive home time, time, date.

58. The computer-readable medium as claimed in claim 51 wherein performance activity is measured by at least one parameter selected from cardio performance, muscular performance, overall performance, time, date.
10

59. The computer-readable medium as claimed in claim 51 wherein environmental activity is measured by at least one parameter selected from temperature, weather forecast, humidity, altitude, terrain.

15 60. The computer-readable medium as claimed in claim 51 wherein Preferably neurocardio activity is measured by at least one parameter selected from posture, respiration, inactive time, heart rate variability, time, date.

61. The computer-readable medium as claimed in any one of claims 45 to 60 wherein
20 the first activity data comprises a plurality of measurements associated to a first set of parameters monitored during the first activity.

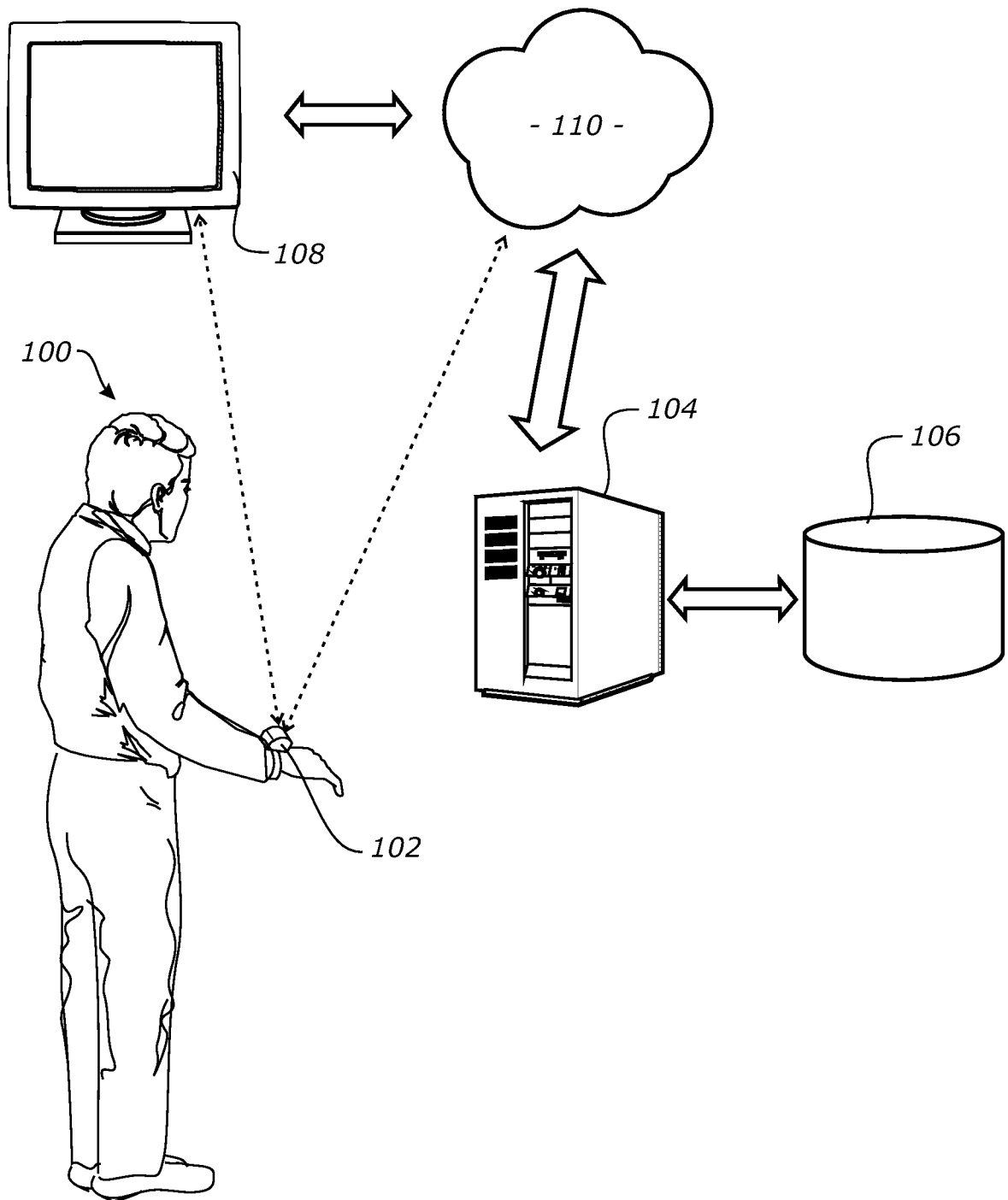
62. The computer-readable medium as claimed in any one of claims 45 to 61 wherein the second activity data comprises a plurality of measurements associated to a second
25 set of parameters monitored during the second activity.

63. The computer-readable medium as claimed in any one of claims 45 to 62 wherein comparing the at least some of the first activity data with respective sets of measurements stored on a tangible computer readable medium comprises comparing the
30 at least some of the first activity data with measurements associated to the at least one parameter monitored during the first activity.

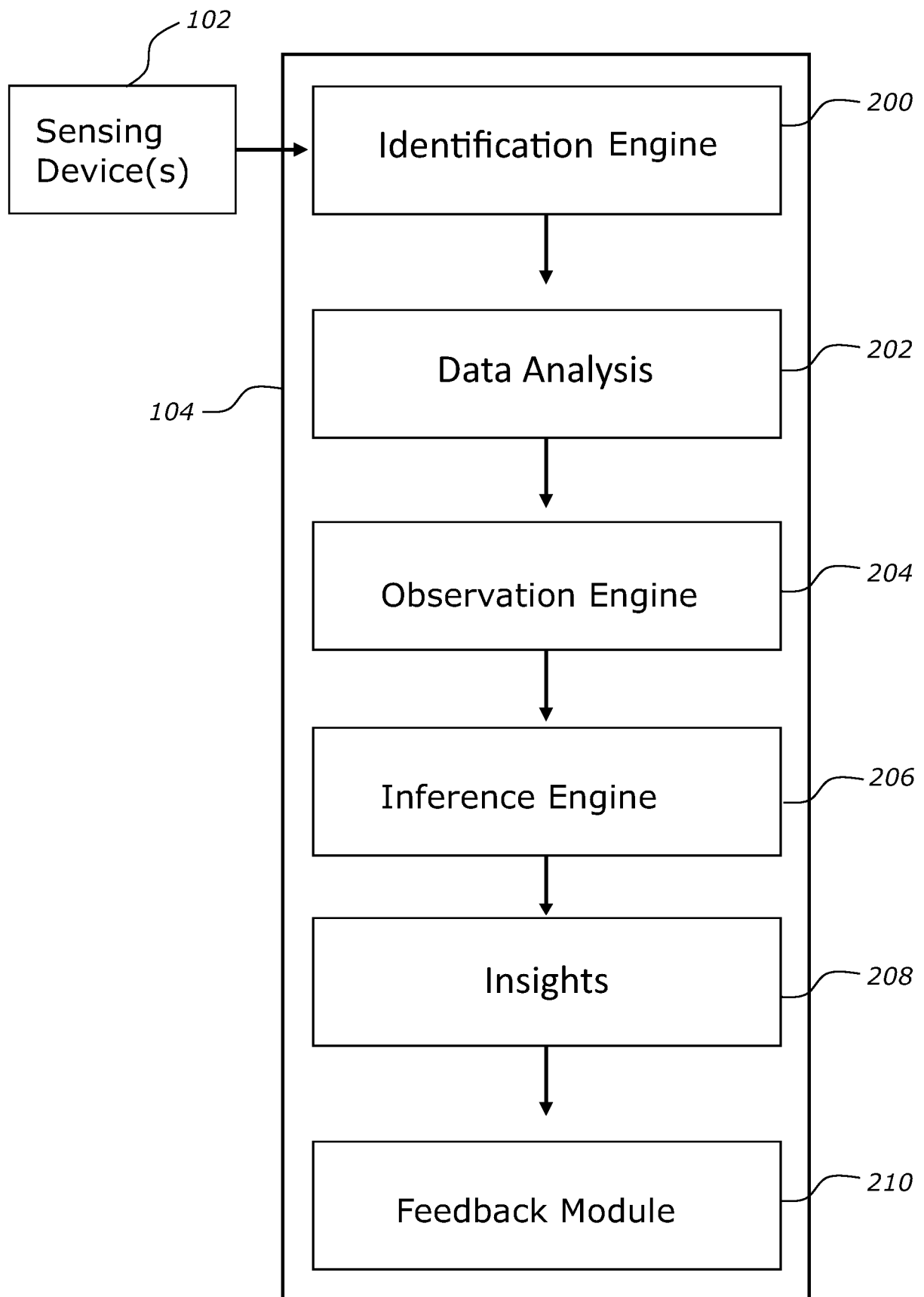
64. The computer-readable medium as claimed in any one of claims 45 to 63 wherein comparing the at least some of the second activity data with respective sets of
35 measurements stored on a tangible computer readable medium comprises comparing the at least some of the second activity data with measurements associated to the at least one parameter monitored during the second activity.

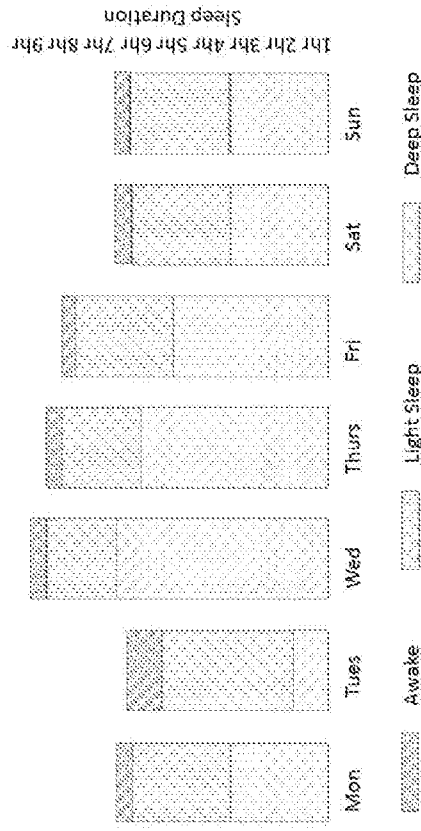
65. The computer-readable medium as claimed in any one of claims 45 to 64 wherein the second time interval is different to the first time interval.
66. The computer-readable medium as claimed in any one of claims 45 to 64 wherein the second time interval overlaps the first time interval.
- 5

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**FIGURE 1**

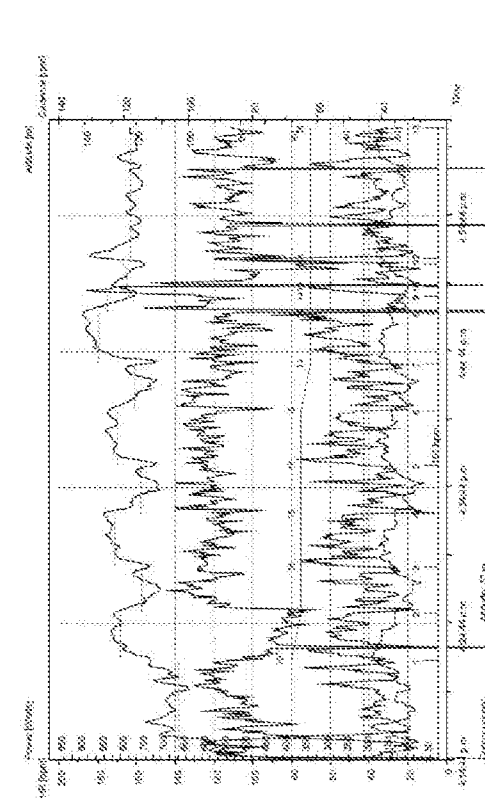
2 / 21

**FIGURE 2**



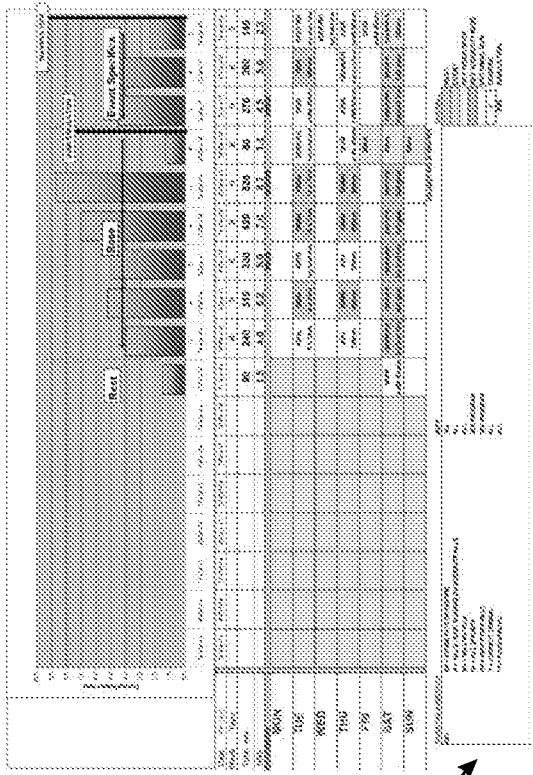
Sleep Activity

302



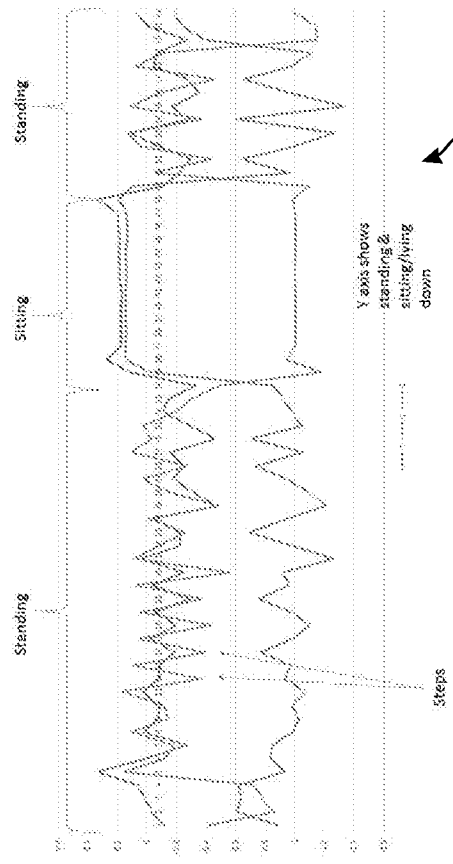
Exercise Activity

300



Exercise Plan & Log

304



General Activity

306

FIGURE 3

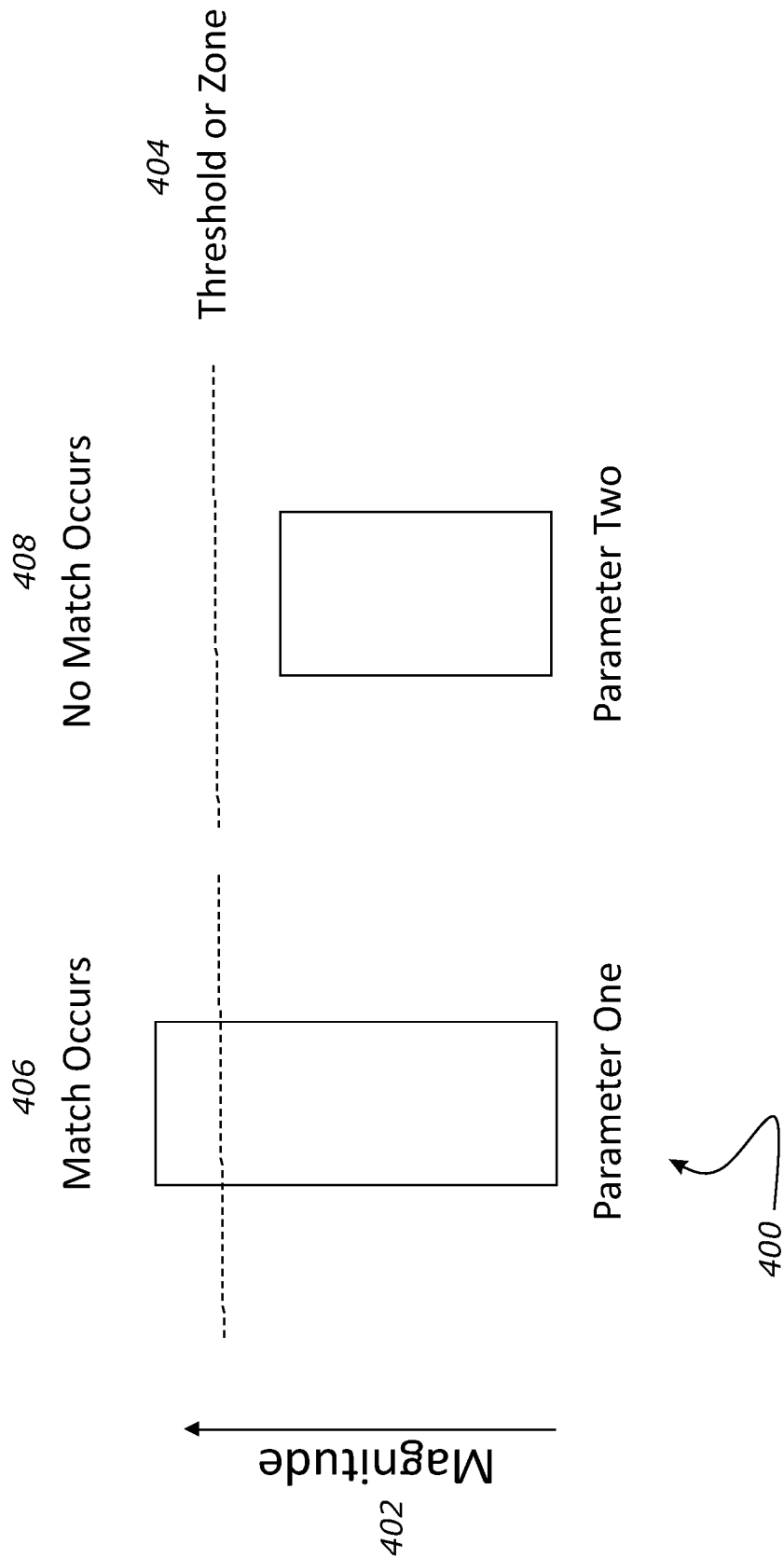


FIGURE 4

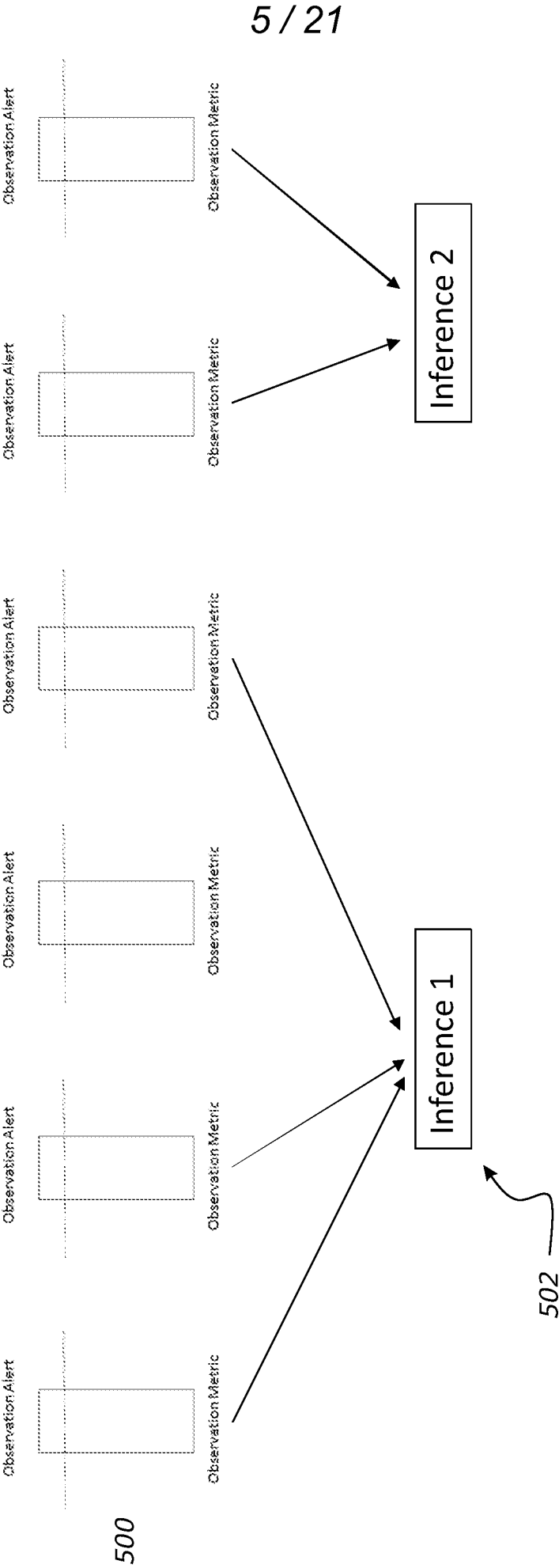


FIGURE 5

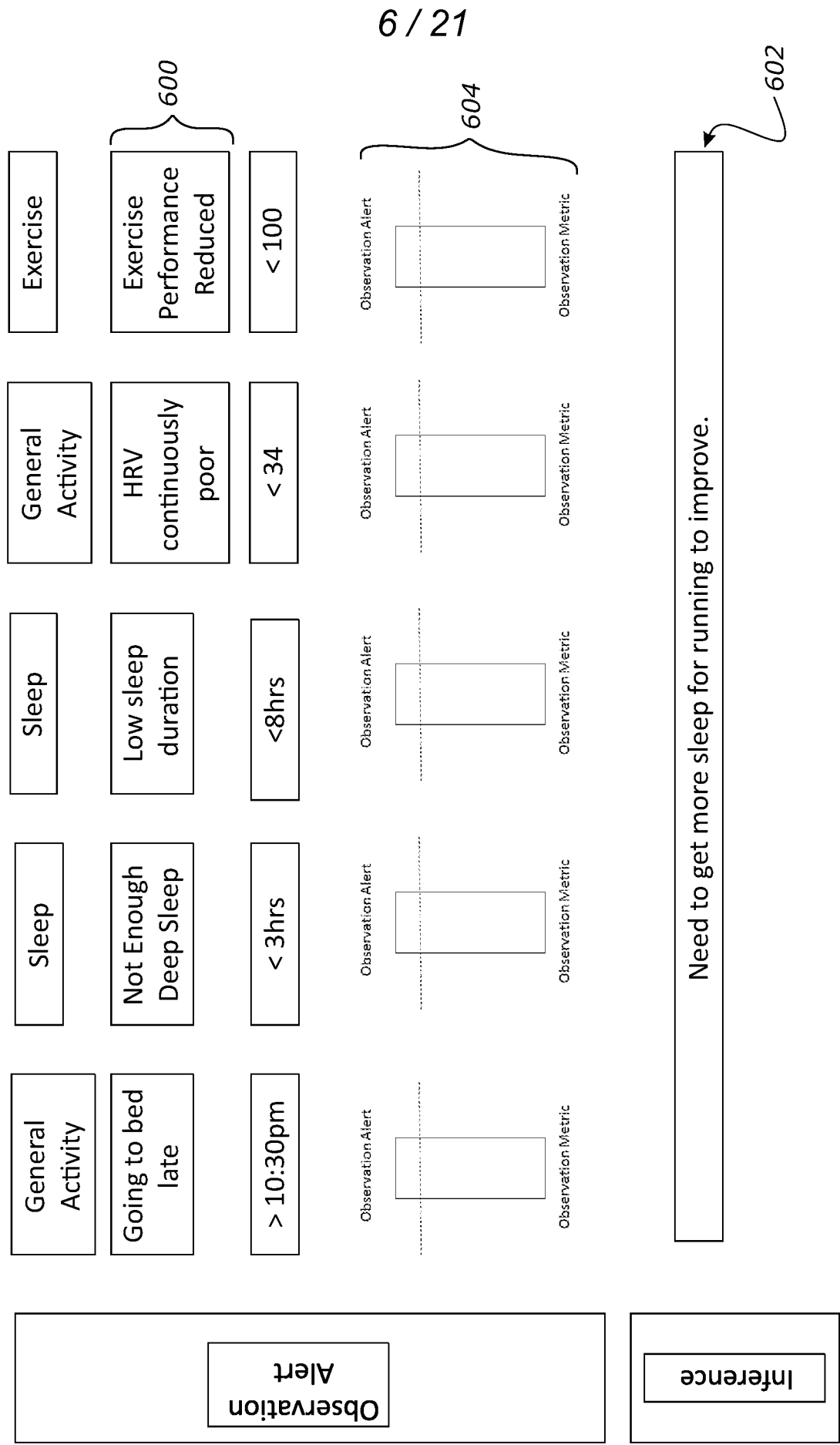


FIGURE 6

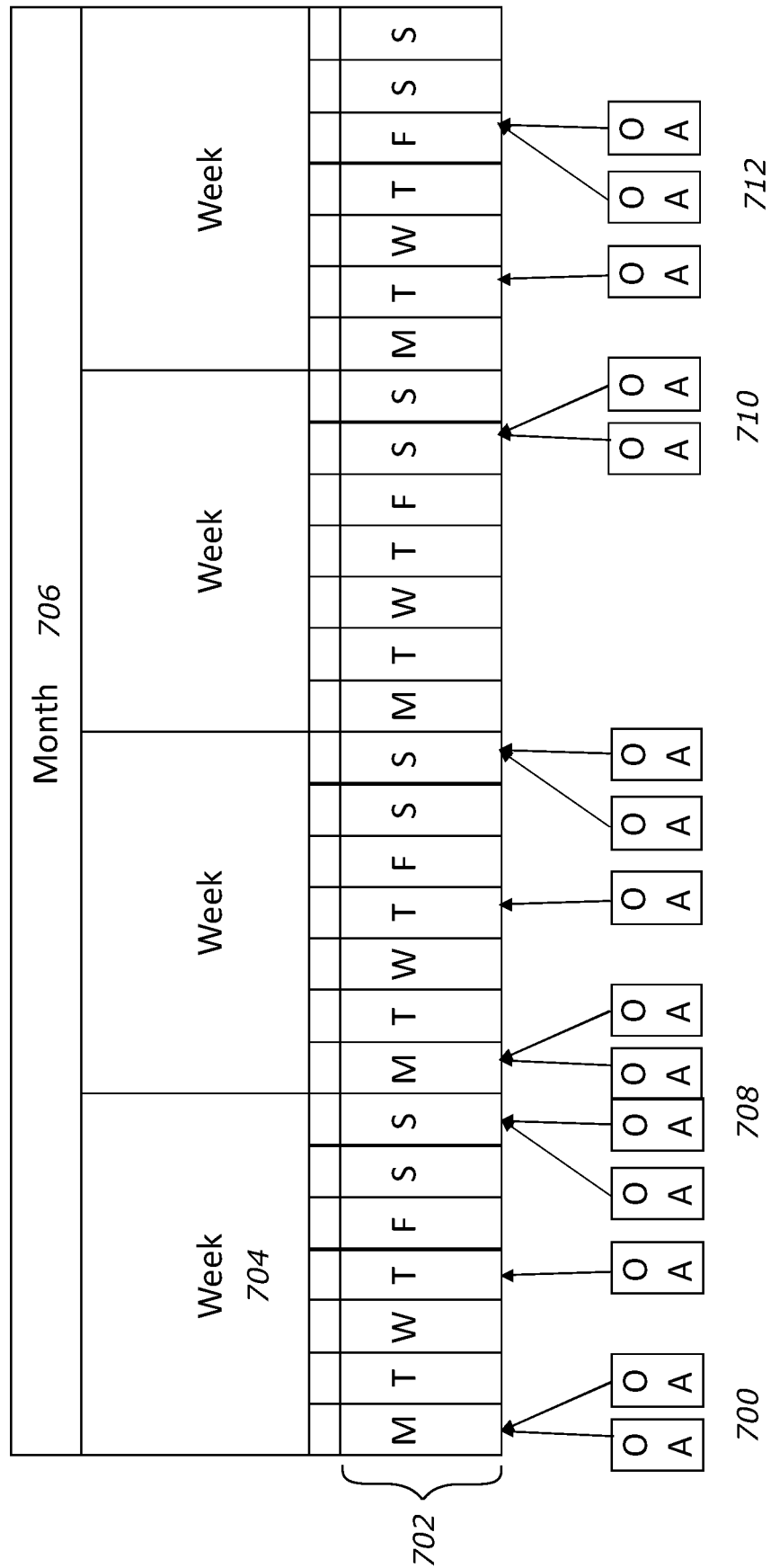


FIGURE 7

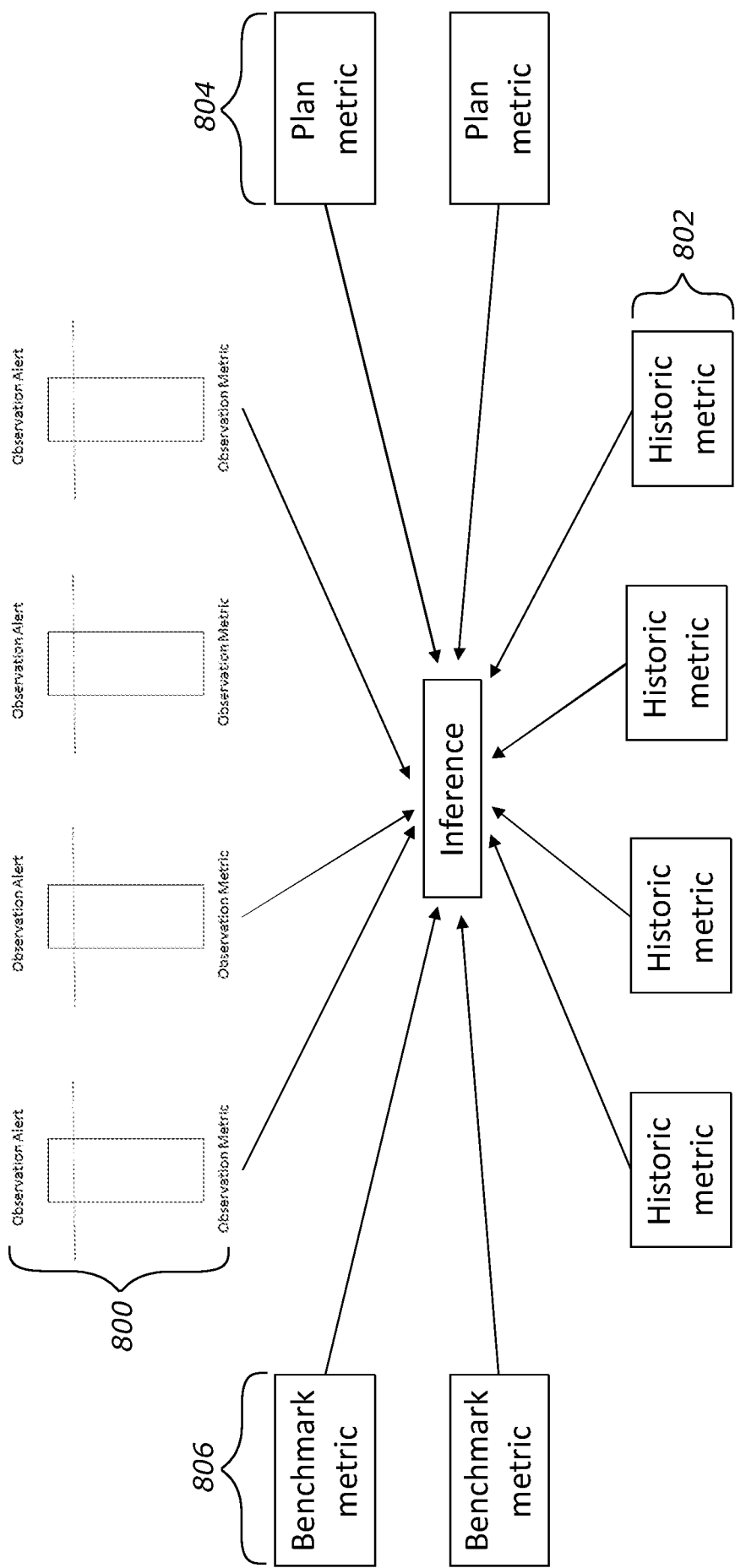


FIGURE 8

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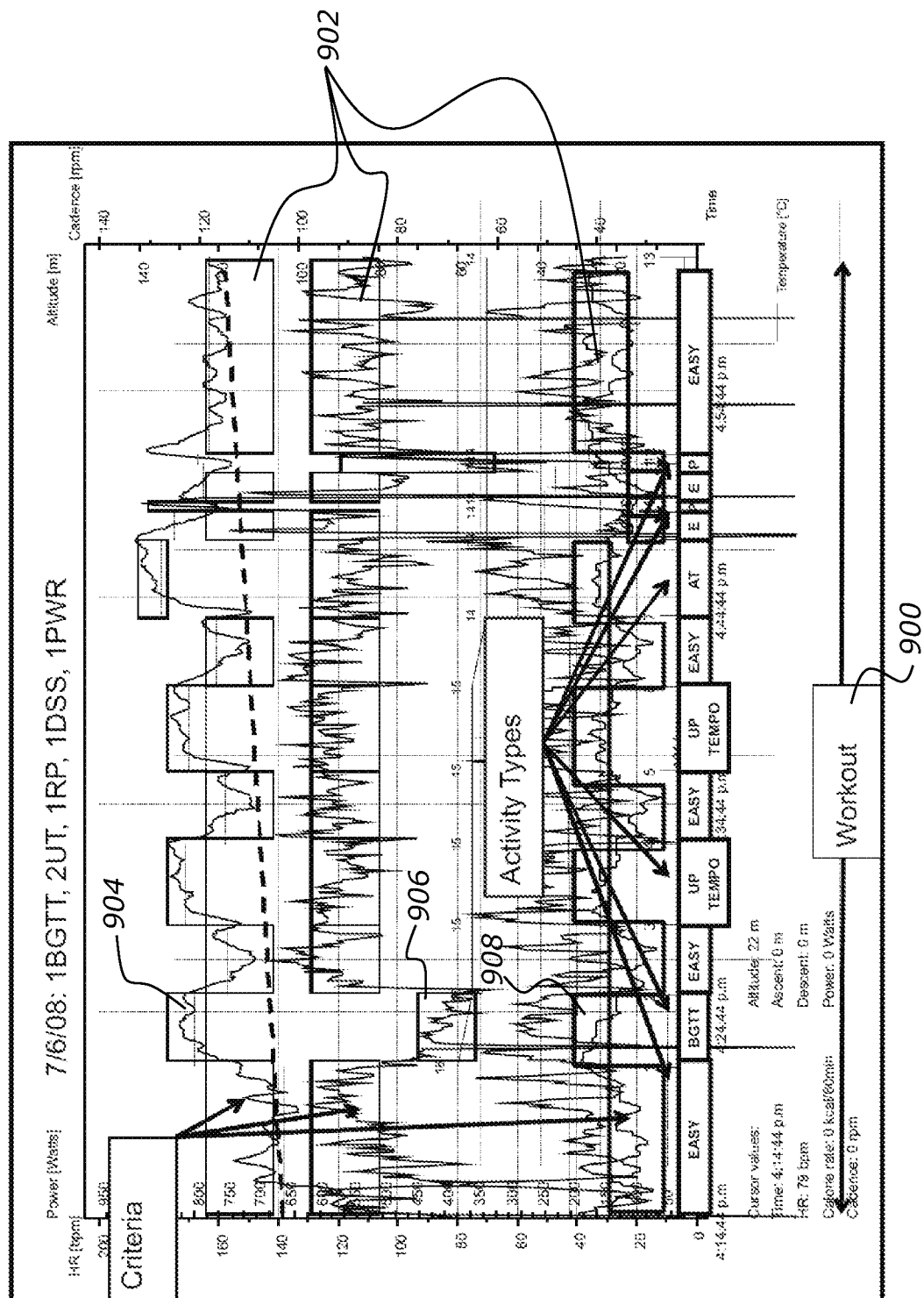


FIGURE 9

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Category	Category Sub Class	Parameter 1	Parameter 2	Parameter 3	Parameter 4	Observation (actual)	Threshold	Condition	Observation Alert
Exercise Activity Running	Hill Climb	(power)	-	-	-	222 watts	< 250 watts	condition met	Too slow climbing
Recuperative Activity Sleep	Total Duration	time lying down (accelerometer)	low movement (accelerometer)	time of day (time)	last 7 days	6.7 hrs	< 7 hrs (average)	condition met	Not enough sleep
	Deep Sleep Duration	time lying down (accelerometer)	low movement (accelerometer)	time of day (time)	-	2.2 hrs	< 3 hrs	condition met	Not enough deep sleep
	Heart Rate Variability	RMSSD (heart rate)	upright (accelerometer)	time of day (time)	-	19	< 22	condition met	Fatigue
Activity/Exercise Plan Training Plan	Plan Duration Compliance	running instances (accelerometer or GPS)	actual running time (accelerometer or GPS)	plan running time (plan data, time)	last 7 days	67%	<90%	condition met	Poor Compliance
	Plan Speed Rep Compliance	Speed rep instances (accelerometer or GPS)	Plan speed rep instances (plan data, time)	-	last 7 days	0%	<90%	condition met	No speed reps completed
General Life Activities	Speed of Movement	stride rate (accelerometer)	-	-	last 24 hrs	45 steps/min	< 60 steps/min	condition met	Very low stride rate
	Amount of Time Stationary	low movement (accelerometer)	upright (accelerometer)	-	last 24 hrs	77% stationary	> 65% stationary	condition met	Low movement today

ALL CONDITIONS MET INFERENCE ALERT GENERATED Inference Alert:
 User is Fatigued, Take it easy for a few days. Do not do tomorrow's workout. Get some sleep.

FIGURE 10

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Sensor Used	Parameters Used	Metric	Threshold	
Chrono, GPS, Proximity, Cell Tower Triangulation	time, location	Average arrival time at work/week, arrival time by day	> 7:45am (learnt)	Life Measures
Chrono, accelerometer	time, motion	High Activity during day	>5,000 steps (pre set)	
Chrono, calendar	calendar appointment times, date	Number of appointments in calendar	>6 appointments in 8hrs (pre set)	
Accelerometer	Torso & Thigh Incline	Postural Status (% time sitting)	Sitting > 60% of waking time (pre set)	
Chrono, GPS, Proximity, Cell Tower Triangulation	time, location	Average arrival time at home/week days	>6pm (learnt)	
Chrono, Activity classification log	Logged Workout Dates & Durations	When did last off season occur?	< 3 months ago (pre set)	Exercise Measures
Chrono, Activity classification log	Logged workout dates	Number of workouts in row/week	> 3 workouts on consecutive days (pre set)	
Chrono, Calendar long term training plan	Scheduled Training Plan volumes	Planned Peak Training Volume Weeks	2 weeks > 4,752,000w (learnt)	
Chrono, activity classification, calendar training plan	Training microcycle plan/logged workouts	Expected workout pattern	Microcycle Plan (e.g. Run = Tues, Thurs, Sat, Bike = Wed, Sun) (Plan data)	
Chrono, workout plan	Training plan scheduled duration/predicted power	Workout cumulative watts	>792,000w in single workout (learnt)	
Chrono, Activity classification, calendar training plan	Training plan scheduled duration/ logged workouts	Compliance to the Training plan scheduled duration	<80% or >120% of Planned Workout Duration (Plan Data)	
Chrono, Activity Type classification, calendar training plan	Training plan scheduled & logged Activity Types	Workout Activity Types completed	<80% completion of planned Activity Types (Plan data)	
Chrono, Activity Type classification, calendar training plan	Scheduled Training plan & logged activity types	Compliance to planned resistance Activity Types	<70% completion of planned resistance Activity Types (Plan data)	
Chrono, Activity Type classification, calendar training plan	Scheduled Training plan & logged activity types	Compliance to planned speed Activity Types	<50% completion of planned speed Activity Types (Plan data)	
Chrono, accelerometer, equipment ID receiver	Equipment ID, consistent fore/aft motion in conjunction with incline of limbs	Reps lifted for Resistance Exercise	number of reps of best result of last 3 workouts (for equipment) (learnt)	
Chrono, accelerometer, equipment ID receiver	Equipment ID, time for consistent fore/aft motion in conjunction with incline of limbs	Rep speed for resistance exercise	faster/slower/same than average of last 3 workouts per equipment	
Chrono, accelerometer, equipment ID receiver	Equipment ID, resistance level (weight/resistance)	Rep weight for resistance exercise	higher/lower/same weight vs average for last 3 workouts per	
Chrono, accelerometer, equipment ID receiver	Equipment ID, time between consistent fore/aft motion in conjunction with incline of limbs	Rest between between reps per exercise or between exercises	120% of prescribed rest period in plan (plan data)	
Physiological Metrics	Standard Performance Algorithm	Muscular Performance	<100 for Performance Algorithm (learnt)	
Physiological Metrics	Standard Performance Algorithm	CV performance	<100 for Performance Algorithm (learnt)	
Chrono, accelerometer, GPS, Proximity, Cell Tower Triangulation	Time, Postural Incline (location)	Average Wake up time/ week	<5:20am average for working week (learnt)	Re recuperative Measures
Chrono, accelerometer, GPS, Proximity, Cell Tower Triangulation	Time, postural incline, (location)	Average Bed time/week	>10:30pm for working week (learnt)	
Chrono, accelerometer, GPS, Proximity, Cell Tower Triangulation	Postural Incline, degree of motion, time, (location)	Average Sleep (Deep) - hrs	<3hrs deep sleep detected (pre set or learnt)	
Chrono, accelerometer, GPS, Proximity, Cell Tower Triangulation	Postural Incline, degree of motion, time, (location)	Average sleep length - hrs	>7.2hrs duration for sleep (pre set or learnt)	
Heart rate, accelerometer, respiration sensor (or inferred), chrono	Heart Rate, Average Time between Heart beats, algorithms, postural incline, time of day, period of below a motion threshold, respiration rate & evenness	Heart Rate Variability (stress/fatigue)	<30 for HRV score (learnt, benchmarked)	
		Posture	Lying, standing, sitting (pre set)	Neurocardio Status
		Time stationary	15mins below motion threshold (pre set)	
		Respiration	Even breathing (stdev) & <13 breaths/min (direct or inferred) (pre set)	
Sensor	Parameter	Detection	Thresholds	

FIGURE 11

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Observation Alert		Observation	Metric	Threshold		
needs an off season	4 mths ago		When did last off season occur?	< 3 months ago (pre set)	Running	Exercise Measures
missing workouts	missed Tu & Th workouts		Expected workout pattern	Microcycle Plan (e.g. Run = Tues, Thurs, Sat, Bike = Wed, Sun) (Plan data)		
too much training effort	>800,000 watts		Workout cumulative watts	>792,000w in single workout (learnt)		
waking too early	5:00		Average Wake up time/ week	<5:20am (0500) average for working week (learnt)	Bed time	Recuperative Measures
going to bed too late	22:42		Average Bed time/week	>10:30pm (2030) for working week (learnt)		
Low quality sleep	3.2		Average Sleep (Deep) - hrs	<3hrs deep sleep detected (pre set or learnt)		
Not enough sleep time	5.3		Average sleep length - hrs	>7.2hrs duration for sleep (pre set or learnt)		
Fatigue Indicated	25		Heart Rate Variability (stress/fatigue)	<30 for HRV score (learnt, benchmarked)	Neurocardio Status	
accurate HRV measure confirmed	sitting		Posture	Lying, standing, sitting (pre set)		
	30min		Time stationary	15mins below motion threshold (pre set)		
	12		Respiration	Even breathing (stdev) & <13 breaths/min (direct or inferred) (pre set)		
Need to take it a bit easier. Back training off and focus on better sleep patterns.			Detection	Thresholds		
			Inference Alert			

FIGURE 12

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		Life Measures	Recuperative Measures							
		Work	Bed time		Neurocardio Status					
Threshold		>6 appointments in 8hrs (pre set)	>10:30pm (2030) for working week (learnt)	>7.2hrs duration for sleep (pre set or learnt)	<30 for HRV score (learnt, benchmarked)	Lying, standing, sitting (pre set)	15mins below motion threshold (pre set)	Even breathing (stdev) & <13 breaths/min (direct or inferred) (pre set)	Thresholds	
Metric		Number of appointments in calendar	Average Bed time/week	Average sleep length - hrs	Heart Rate Variability (stress/fatigue)	Posture	Time stationary	Respiration	Detection	
Observation		7	23:42	6	25	sitting	30min	12	Inference Alert	
Observation Alert		You have a busy day tomorrow	You are going to bed too late.	You are not getting enough sleep	Fatigue Indicated	acurate HRV measure confirmed			Your sleep habits have been poor lately. You are tired and need to get to bed early as you have a busy day tomorrow.	

FIGURE 13

Threshold	Life Measures				Recuperative Measures				Inference Alert	Detection	Thresholds			
	Work				Neurocardio Status									
Observation	n Alert	Observation	Metric	Threshold	Observation	n Alert	Observation	Metric	Threshold	Observation	n Alert	Observation	Metric	Threshold
Consistently arriving at work early	7:00	Average arrival time at work/week, arrival time by day	> 7:45am (0745) (learn't)	>5,000 steps (pre set)	High work day activity	18,000	High Activity during day	Number of appointments in calendar	>6 appointments in 8hrs (pre set)	Average arrival time at home/week days	>6pm (1800) (learn't)	Slight Fatigue indicated	Heart Rate Variability (stress/fatigue)	<30 for HRV score (learn't, benchmarked)
Consistently arriving at work late	19:23	Average arrival time at home/week days	>6pm (1800) (learn't)	>6pm (1800) (learn't)	Consistently Arriving at home late	19:23	Average arrival time at home/week days	Heart Rate Variability (stress/fatigue)	<30 for HRV score (learn't, benchmarked)	Ly'ing, standing, sitting (pre set)	15mins below motion threshold (pre set)	acurate HRV measure confirmed	Time stationary	15mins below motion threshold (pre set)
High Appointment load	8	Number of appointments in calendar	>6 appointments in 8hrs (pre set)	>6pm (1800) (learn't)	High work day activity	18,000	High Activity during day	Number of appointments in calendar	>6 appointments in 8hrs (pre set)	Even breathing (stdev) & <13 breaths/min (direct or inferred) (pre set)	>6pm (1800) (learn't)	Respiration	Even breathing (stdev) & <13 breaths/min (direct or inferred) (pre set)	>6pm (1800) (learn't)
Your workload is very high.														

FIGURE 14

Threshold	Exercise Measures				Recuperative Measures			
	Running				Neurocardio Status			
Metric	Microcycle Plan (e.g. Run = Tues, Thurs, Sat, Bike = Wed, Sun) (Plan data)	<80% or >120% of Planned Workout Duration (Plan Data)	<80% completion of planned Activity Types (Plan data)	<70% completion of planned resistance Activity Types (Plan data)	<50% completion of planned speed Activity Types (Plan data)	Performance		
	Expected workout pattern	Compliance to the Training plan scheduled duration	Workout Activity Types completed	Compliance to planned resistance Activity Types	Compliance to planned speed Activity Types	CV performance		
Observation	missed Tu & Th workouts	60%	50%	50%	120%	80	80	acurate HRV measure confirmed
	Missing too many workouts	Duration Compliance low	Activity Types Compliance Low	Resistance Activity Types Compliance Low	Speed Activity Types Compliance Low, TOO MUCH	Muscular Performance deteriorating	CV performance deteriorating	
Inference Alert	Your performance is dropping & your fatigue levels are increasing. You are also missing too many workouts. This is because you are doing too much speed training at not following the plan well.				25	sitting	30min	12
	Heart Rate Variability (stress/fatigue)				Posture	Time stationary	Respiration	Even breathing (stdev) & > 13 breaths/min (direct or inferred) (pre set)
Detection								
Thresholds								

FIGURE 15

Exercise Measures					Recuperative Measures											
Threshold	Running	Gym			Performance		Bed time			Neurocardio Status						
	Microcycle Plan (e.g. Run = Tues, Thurs, Sat, Bike = Wed, Sun) (Plan data)	number of reps of best result of last 3 workouts (for equipment) (learnt)	faster/slower/same than average of last 3 workouts per equipment (learnt)	higher/lower/same weight vs average for last 3 workouts per equipment (learnt)	120% of prescribed rest period in plan (plan data)	<100 for Performance Algorithm (learnt)	<100 for Performance Algorithm (learnt)	Average Wake up time/ week (<5:20am (0520) average for working week (learnt)	>10:30pm (2030) for working week (learnt)	<3hrs deep sleep detected (pre set or learnt)	>7.2hrs duration for sleep (pre set or learnt)	<30 for HRV score (learnt, benchmarked)	Lying, standing, sitting (pre set)	15mins below motion threshold (pre set)	Even breathing (stdev) & < 13 breaths/min (direct or inferred) (pre set)	
Metric	Expected workout pattern	Reps lifted for Resistance Exercise	Rep speed for resistance exercise	Rep weight for resistance exercise	Rest between between reps per exercise or between exercises	Muscular Performance	CV performance	Average Bed time/week	Average Sleep (Deep) - hrs	Average sleep length - hrs	Heart Rate Variability (stress/fatigue)	Posture	Time stationary	Respiration	Detection	
Observation	Good workout pattern	reps increasing	speed of lifts the same	weight increasing	100%	110	100	7:00	22:30	3.2	8.2	57	sitting	30min	12	Inference Alert
Observation	Excellent workout pattern	Doing more reps for same weight	Speed of reps is good	Lifting heavier weights	Not resting too much between sets	Muscular Performance is increasing	CV performance is increasing	Wake up time is good	Bed time is not too late	Amount of deep sleep is good	Average amount of sleep is good	Recovery levels are good	acurate HRV measure confirmed	Excellent work. You are managing recuperation well, your gym training is being completed thoroughly and you are getting the performance rewards for this.		

FIGURE 16

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	Exercise Measures							Re recuperative Measures						
	Running				Gym		Performance		Neurocardio Status					
Threshold	< 3 months ago (pre set)	>792,000w in single workout (learnt)	<80% or >120% of Planned Workout duration (Plan Data)	<80% completion of planned Activity Types (Plan data)	number of reps of best result of last 3 workouts (for equipment) (learnt)	higher/lower/same weight vs average for last 3 workouts per equipment (learnt)	<100 for Performance Algorithm (learnt)	<100 for Performance Algorithm (learnt)	<30 for HRV score (learnt, benchmarked)	Lying, standing, sitting (pre set)	15mins below motion threshold (pre set)	Even breathing (stdev) & <13 breaths/min (direct or inferred) (pre set)	Thresholds	
Metric	When did last off season occur?	Workout cumulative watts	Compliance to the Training plan scheduled	Compliance to planned resistance Activity Types	Compliance to planned speed Activity Types	Reps lifted for Resistance Exercise	Rep weight for resistance exercise	Muscular Performance	CV performance	Heart Rate Variability (stress/fatigue)	Posture	Time stationary	Respiration	Detection
	Inference Alert													
Observation	5 months	792,000	100%	100%	100%	100%	reps number remains static	rep weight is not increasing	90	88	22	sitting 30min	12	You are training well BUT you need some long term rest which is known as an off season. Improvements will not happen until you have recovered from the accumulated training load of the last few months.
Observation Alert	Needs an off season	Workload per workout is good	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	gym work not improving	gym work not improving	Muscular Performance is deteriorating	CV performance is deteriorating	High Fatigue levels	accurate HRV measure confirmed		

FIGURE 17

Exercise Measures						
Threshold	Gym				Performance	
	number of reps of best result of last 3 workouts (for equipment) (learnt)	faster/slower/same than average of last 3 workouts per equipment (learnt)	higher/lower/same weight vs average for last 3 workouts per equipment (learnt)	Rest between reps per exercise or 120% of prescribed rest period in plan (plan data)	<100 for Performance Algorithm (learnt)	<100 for Performance Algorithm (learnt)
Metric	Reps lifted for Resistance Exercise	Rep speed for resistance exercise	Rep weight for resistance exercise	Rest between between reps per exercise or between exercises	Muscular Performance	CV performance
Observation	Reps lifted aren't changing	Rep speed has decreased	Weights lifted are not changing	115%	96	100
Observation Alert	No improvement in the number of reps lifted	Rep speed has gotten worse	Weights lifted are not increasing	Resting a little too long between sets	Muscular Performance is deteriorating	CV performance is static
You are muscularly tired. Let's have a rest from gym work tomorrow. We need to rest up to start improving again.						
Inference Alert						
Detection						
Thresholds						

FIGURE 18

Exercise Measures						Re recuperative Measures		
Running						Neurocardio Status		
Threshold	workout (learnt)	<80% or >120% of Planned Workout Duration (Plan Data)	<80% completion of planned Activity Types (Plan data)	<70% completion of planned resistance Activity Types (Plan data)	<50% completion of planned speed Activity Types (Plan data)	<100 for Performance Algorithm (learnt)	<100 for Performance Algorithm (learnt)	
Observation Alert	Too much load in the workout	Not following the training plan duration very well	Only doing about half of the planned Activity Types	Not doing enough hill work	Too much speed training being done.	Muscular Performance is OK	CV performance is dropping	acurate HRV measure confirmed
	896,000	70%	60%	30%	140%	87	67	
Observation	Workout cumulative watts	Compliance to the Training plan scheduled duration	Workout Activity Types completed	Compliance to planned resistance Activity Types	Compliance to planned speed Activity Types	Muscular Performance	CV performance	Low levels of fatigue
Inference Alert	Detection	Thresholds	Heart Rate Variability (stress/fatigue)	Lying, standing, sitting (pre set)	15mins below motion threshold (pre set)	Even breathing (stdev) & <13 breaths/min (direct or inferred) (pre set)	Respiration	
			Posture	sitting	30min	12		
			Time stationary					
Exercising way too hard and not following the plan. Too tired. You need to back off the speed training and do some hill work instead. You will improve more and won't get as tired.								

FIGURE 19

20 / 21

Threshold	Exercise Measures										Re recuperative Measures			
	Running										Performance			
Observation Alert	Off Season is up to date	Too many workouts in a row	Biggest volume week in the plan is next week	2 months	12	Next wk	keeps doing extra workouts	Workouts are of the correct load	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent
	When did last off season occur?	Number of workouts in row/week	Planned Peak Training Volume Weeks	Expected workout pattern	Workout cumulative watts	Compliance to the Training plan scheduled duration	Workout Activity Types completed	Compliance to planned resistance Activity Types	Compliance to planned speed Activity Types	CV performance	Heart Rate Variability (stress/fatigue)	Posture	Time stationary	Respiration
Observation	Doing too much extra training which is causing fatigue. Not good just before you peak mileage week for the program which is next week. Back off & recover to get ready for this.	Doing more than is needed training wise	Workouts are of the correct load	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent	Compliance is excellent
	2 months	12	Next wk	keeps doing extra workouts	750,000	100%	100%	100%	100%	90	28	sitting	30min	12
Metric	When did last off season occur?	Number of workouts in row/week	Planned Peak Training Volume Weeks	Expected workout pattern	Workout cumulative watts	Compliance to the Training plan scheduled duration	Workout Activity Types completed	Compliance to planned resistance Activity Types	Compliance to planned speed Activity Types	CV performance	Heart Rate Variability (stress/fatigue)	Posture	Time stationary	Respiration
	2 months	12	Next wk	keeps doing extra workouts	750,000	100%	100%	100%	100%	90	28	sitting	30min	12
Threshold	When did last off season occur?	Number of workouts in row/week	Planned Peak Training Volume Weeks	Expected workout pattern	Workout cumulative watts	Compliance to the Training plan scheduled duration	Workout Activity Types completed	Compliance to planned resistance Activity Types	Compliance to planned speed Activity Types	CV performance	Heart Rate Variability (stress/fatigue)	Posture	Time stationary	Respiration
	2 months	12	Next wk	keeps doing extra workouts	750,000	100%	100%	100%	100%	90	28	sitting	30min	12

FIGURE 20

FIGURE 21

Life Measures			Exercise Measures		Recuperative Measures												
Threshold	Metric	Observation	n Alert	Too much time sitting	No exercise this week	Lower quality sleep	Excellent recovery levels	acurate HRV measure confirmed	12	15min	sitting	Time stationary	Respiration	Neurocardio Status			
														Work	Running	Bed time	Even breathing (stdev) & <13 breaths/min (direct or inferred) (pre set)
Inference Alert	Detection	You are currently too inactive. Ideally you should do more exercise. This should help your sleep quality too.	Observation	83%	no ex/wk	2.2	32	sitting	15min	12	Time stationary	Respiration	Even breathing (stdev) & <13 breaths/min (direct or inferred) (pre set)	15mins below motion threshold (pre set)	Lyng, standing, sitting (pre set)	<30 for HRV score (learnt, benchmarked)	

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2015/059907

A. CLASSIFICATION OF SUBJECT MATTER

G06F 19/24 (2011.01) A63B 24/00 (2006.01) A61B 5/0205 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

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

EPODOC: CPC A63B24/0075/LOW, A63B2220, A63B2230, A63B2225/20/LOW, A63B2250/50/LOW, A63B2024/0068, G06F19/345, A63B2024/0012, A61B5/0205, A61B5/746, G06F19/3443, G08B in various combinations

EPODOC: G06F19/345, G07F19/3443 and in English language cluster TXTE; infer, alarm, alert

WPIAP: IPC A63B, G06F and keywords activit, sport, work out, cardio monitor, record, observ, compare, threshold, alert and the like terms.

Espacenet Interface, IP Australia Internal databases: Applicant and inventor search

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 4 May 2016	Date of mailing of the international search report 04 May 2016
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaaustralia.gov.au	Authorised officer Matthew Forward AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. +61262832606

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/IB2015/059907
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008/0157980 A1 (SACHANANDANI et al.) 03 July 2008 Paragraphs 0074 to 0078, 0089 to 0094, 0103 Figure 2	1 - 66
X	WO 2009/118399 A2 (UNIVERSITE DE RENNES 1 et al.) 01 October 2009 Abstract, page 15 lines 12-21, page 7 line 23 to page 8 line 25, page 16 line 23 to page 17 line 8, page 20 lines 12 to 19, page 22 lines 10-12, page 26 line 10 to page 27 line 17, Figures 1A, 7-13	1 - 66
X	US 2013/0278414 A1 (SPRIGG et al.) 24 October 2013 Paragraphs 0002, 0022, 0029-0030, 0051-0055, 0085, 0091-0097, figures 1-3, 6	1 - 66
X	US 2008/0284582 A1 (WANG et al.) 20 November 2008 Paragraphs 0006, 0007, 0023, figures	1 - 66
X	US 2012/0323086 A1 (HANSEN) 20 December 2012 Abstract, figures 6 to 8, paragraphs 0002, 0036 to 0039, 0042, 0045, 0047 to 0049, 0061, 0062 to 0067	1 - 66
A	US 8784115 B1 (CHUANG) 22 July 2014	1, 23, 45
A	US 2007/0219059 A1 (SCHWARTZ et al.) 20 September 2007	1, 23, 45
A	EP 1107158 B1 (CARDIAC INTELLIGENCE CORPORATION) 26 March 2008	1, 23, 45
A	US 2011/0092337 A1 (SRINIVASAN et al.) 21 April 2011	1, 23, 45
P,X	US 2015/0080670 A1 (FLINT HILLS SCIENTIFIC, L.L.C.) 19 March 2015 Figures 2, 3 to 9, paragraphs 0008, 0009, 0109, 0113, 0158 to 0160	1-66

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