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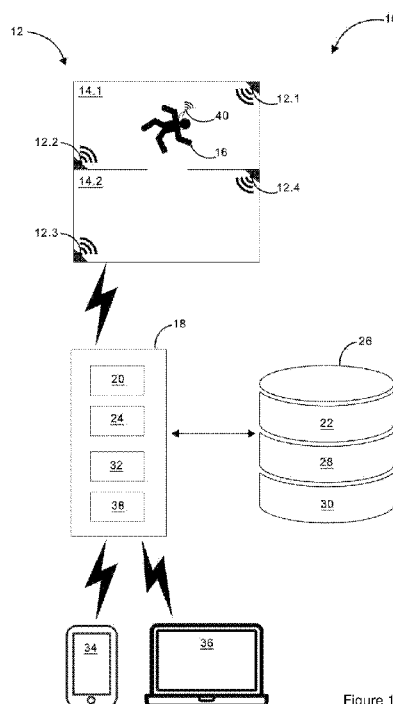


Figure 1

(57) **Abstract:** A usage monitoring system (10) comprising a sensor installation (12) installable in at least one living zone (14) of a user (16) and operable to capture any one or both of real-time motion data and usage data in the at least one living zone in a nonintrusive manner, and a processing unit (18) in communication with the sensor installation and operable to receive the real time motion data and the usage data from the sensor installation (12). Also included is a usage recognition (20) module integrated with the processing unit (18) and having access to a usage identification library (20) populated with pre-recorded usage patterns. The usage recognition module (20) is operable to: synthesise the real-time motion data and the usage data into a real time activity usage pattern, compare the real time activity usage pattern to the pre-recorded usage patterns in the usage identification library, and activate an alarm module if a risk match is obtained between the real time activity usage pattern and the pre-recorded usage patterns. In this manner, system (10) is able

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to monitor personal activity of a user in a nonintrusive manner.

PERSONAL MOTION MONITORING

TECHNICAL FIELD

[0001] This invention relates to personal motion monitoring. More specifically, this invention relates to a usage monitoring system and a method of monitoring usage of at least one living zone to identify risks.

BACKGROUND ART

[0002] The following discussion of the background art is intended to facilitate an understanding of the present invention only. The discussion is not an acknowledgement or admission that any of the material referred to is or was part of the common general knowledge as at the priority date of the application.

[0003] Personal emergency response systems (PERS), also referred to as medical alert systems or alarms, allow a user to signal for help in the case of a medical emergency, such as a fall. Users are typically the elderly or physically disabled. Traditionally, users alerted a responder(s) that they require attention by activating a personal mobile transmitter which is worn on the user. The obvious drawback of these devices is that user consciousness is required for activation.

[0004] To address this drawback, personal mobile transmitters were enhanced to include technologies such as accelerometers, barometric sensors, gyroscopes and/or a highly accurate global positioning system (GPS). Together with proprietary algorithms, these mobile PERS detect hazardous movements, such as falls. The unavoidable drawback of the additional technology is increased cost, resulting in reduced market penetration. Furthermore, with bulky wearable devices, users often complain of wearer discomfort.

[0005] Conventional PERS, such as those described in **US 2016/0360965 A1** and **EP 1071055 A1**, generally relies on wearable

sensors to track user activity and motion. As a result, such conventional PERS are typically unable to track activity or patterns of behaviours for individuals residing in shared accommodation or residences.

[0006] The art thus turned to installed, camera-based PERS, which typically involve the installation of cameras within the living areas of the user. Barring the intrusion on a user's privacy, a major drawback of such camera-based PERS is the high cost of equipment, as well as the cost of installation due to the complex setup required. Furthermore, intensive computation is required to store and analyse live-stream video or camera feed. Field of view can also be a limiting factor in the efficacy of camera-based PERS.

[0007] The present invention was conceived with the goal in mind to address the shortcomings of wearables and/or intrusive and expensive camera systems for accurate and reliable personal motion monitoring.

SUMMARY OF THE INVENTION

[0008] In this specification, the terms "movement" and "motion" are considered interchangeable. Additionally, reference herein to capturing data in a nonintrusive manner specifically refers to means able to monitor a presence of a user without requiring direct photographic data of said user, nor requiring a sensor mounted on a person of such user, i.e. monitoring that does not encroach on a user's privacy.

[0009] According to one aspect of the invention there is provided a usage monitoring system comprising:

a sensor installation installable in at least one living zone of a user, the sensor installation operable to capture any one or both of real-time motion data and usage data in the at least one living zone in a nonintrusive manner;

a processing unit in communication with the sensor installation, operable to receive the real time motion data and the usage data from the sensor installation;

a usage recognition module integrated with the processing unit, the usage recognition module having access to a usage identification library populated with pre-recorded usage patterns, the usage recognition module operable to:

- synthesise the real-time motion data and the usage data captured by the sensor installation into a real time activity usage pattern,
- compare the real time activity usage pattern to the pre-recorded usage patterns in the usage identification library, and
- activate an alarm module if a risk match is obtained between the real time activity usage pattern and the pre-recorded usage patterns; and

an alarm module integrated with the processing unit, the alarm module activated by the usage recognition module when a risk match is obtained;

wherein the system is able to monitor personal activity of a user in a nonintrusive manner.

[0010] The usage monitoring system may include a database storing at least user data and responder data, the database being accessible by the alarm module. The database may be a cloud-based database. The database may be accessible through one or more gateways.

[0011] It is to be appreciated that the user data may include data related to a single user or data related to multiple users, thereby providing for the usage recognition module to access pre-recorded usage patterns of multiple users. This ensures that the invention finds application in a multiple user installation.

[0012] The usage monitoring system may be sensor-agnostic. The sensor installation may include any one or combination of: microwave sensors, passive infrared sensors, area reflective sensors, ultrasonic motion sensors, movement sensors, presence sensors, or the like. It is to be appreciated that all such sensors are nonintrusive.

[0013] In one embodiment, the sensor installation may be operable to detect movement in the at least one living zone by means of a movement detection sensor, such as a passive infrared sensor or an ultrasonic sensor, operable to provide a digital "detection"/"no-detection" indication as the real time motion data. The real time motion data may thus be in the form of a digital detection indication over a period of time for normal usage of the at least one living zone.

[0014] The sensor installation may be further operable to detect usage of components in the at least one living zone by means of a usage detection sensor to provide a digital "use"/"no-use" indication as the usage data. The usage data may thus be in the form of a digital detection indication over a period of time for normal usage of the at least one living zone.

[0015] The pre-recorded usage patterns may be synthesised from digital detection indications of motion and usage over a period of time for normal usage of the at least one living zone.

[0016] The real time motion data and/or the usage data may be timestamped.

[0017] The sensor installation may include an Internet of Things (IoT) hub operable to receive and compile the real time motion data and the usage data from various sensor types. The IoT hub may be cloud-based. The IoT hub may be further operable to monitor the battery life and/or connection status of the sensors, auxiliary sensors, wearable devices, or the like. In the embodiment in which the IoT hub is cloud based, the processing unit may form part of the cloud-based components.

[0018] The usage identification library may be in the form of a database of pre-recorded usage patterns over a period of time for the at least one living zone. The usage identification library may be populated with pre-recorded usage patterns for normal usage of the at least one living zone. The usage identification library may be populated by means of any one or more of: manually defined data patterns, algorithmically defined data patterns, in an automated fashion by machine learning implementations, or the like.

[0019] The pre-recorded usage patterns may include motion patterns, usage patterns, durations, time trends, day trends, or the like.

[0020] The motion patterns may include normal motion patterns, risk motion patterns, unidentified motion patterns or the like, associated with user activity habits, user bathroom habits, user sleep habits, user meal habits, user social habits or the like. In addition, the motion patterns may include exceptional motion patterns operatively to define exceptions to normal motion patterns.

[0021] The normal motion patterns may include motion patterns which were previously recognisable as normal, day-to-day or occasional motions of users. In addition, the normal motion patterns may include motion patterns which are unique to the user.

[0022] The risk motion patterns may include any one or more of: motion patterns which were previously recognised as deviations from the normal motion patterns, motion patterns which were previously recognised as restricted movement patterns, otherwise atypical motion patterns of the user, or the like. Examples of risk motion patterns may include: decreased movement in a living zone, lack of movement in a living zone, unexpected movement in a particular living zone, a user detected as spending an atypical amount of time in a living zone, a user

detected as remaining in a living zone for an atypical amount of time; or the like. More specific examples of risk motion patterns may include: movement in a living zone and sudden no further movement in that living zone; movement in a living zone and sudden limited movement in that living zone but no other living zones; or the like.

[0023] The unidentified motion patterns may include motion patterns which were previously detected but could not be successfully identified or categorised (as either normal motion patterns, risk motion patterns or exceptional motion patterns).

[0024] The usage patterns may include any one or more of: door usage patterns, device usage patterns, appliance usage patterns, cupboard usage patterns, or the like.

[0025] The pre-recorded usage patterns in the usage identification library may be grouped according to specific living zone(s) of the user, selected from the following living zones: bedroom, bathroom, kitchen, lounge, garage, or the like. Each living zone may have a zone risk factor associated therewith. The zone risk factor may be predefined or may be determined by the usage monitoring system based on any content of the living zone.

[0026] The pre-recorded usage patterns in the usage identification library may be grouped according to specific days of the week and/or specific times within a day(s).

[0027] The usage recognition module may be operable to consider any one or more of the following when comparing the real time activity usage pattern to the pre-recorded usage patterns: specific living zone(s), specific day, specific time, risk factors associated with any one or more of the aforementioned, or the like.

[0028] The usage recognition module may be operable to recognise an onset of a risk motion pattern and obtain a risk

match to activate the alarm module. Advantageously, this allows responders to react proactively prior to a risk materialising if possible.

[0029] The risk match may comprise any one or both of: at least a partial match between the real time activity usage pattern synthesised and a risk motion pattern; and at least a partial match between the real time activity usage pattern synthesised and an unidentified motion pattern. Other risk factors and data may be included in determining whether a risk match is obtained, being received by the usage recognition module and including any one or more of the zone risk factor, the time risk factor, the user acceptable risk factor, or the like.

[0030] The alarm module may be operable to validate a risk match obtained from the usage recognition module. In particular, the alarm module may compare a risk match with a data structure store. The data structure store may be an in-memory remote dictionary server. The data structure store may include any one or more of: sensor states, household states, time states or the like.

[0031] The alarm module may be operable to dispatch an alarm notification to a responder, using the responder data on the database, when a risk match is validated. The alarm notification may be in the form of any one or more of: a push notification, an email notification, a short message service (SMS) or the like. The alarm notification may include the user data of the particular user at risk. The alarm notification may further include any one or both of: the risk match and the real time motion data and the usage data, such that a responder can evaluate a risk.

[0032] The alarm module may be further operable to escalate an alarm notification to a further responder(s) should no response from an initial responder be detected within an acceptable timeframe.

[0033] The usage monitoring system may include one or more auxiliary sensors operable to augment the real time motion data processing by the processing unit, by providing the usage data.

[0034] In particular, the one or more auxiliary sensors may include power sensors integrated with devices operable to update the processing unit on usage. For example, if no movement is detected in a living room after some movement, a power sensor integrated with a television may indicate usage of the television, influencing whether a risk match is obtained by the processing unit. In another example, a power sensor integrated with a stove/oven may indicate prolonged usage of the appliance, to determine normal motion patterns in the kitchen.

[0035] The one or more auxiliary sensors may also include door sensors installed on one or more doors operable to update the processing unit on usage. For example, if a door sensor on the front door is activated, the door sensor will signal to the processing unit that a person entered the at least one living zone. The timestamp of this signal may assist in determining a normal motion pattern.

[0036] The one or more auxiliary sensors may further include open-close sensors installed on cupboard doors, appliances or the like, operable to update the processing unit on usage. For example, an open-close sensor installed on a pantry door may update the processing unit on meal activities to determine normal motion patterns in the kitchen.

[0037] The one or more auxiliary sensors may yet further include temperature sensors installed in the at least one living zone, operable to update the processing unit on real time temperatures in each living zone.

[0038] The user data may include any one or combination of: a user name, a user identifier, a user address, a user emergency contact, a user next of kin, a user do-not-resuscitate (DNR) order status, a user disability level, a user health risk(s), a

user medical history, a user genetic predisposition(s), a user acceptable risk factor, user-associated documents or the like.

[0039] The user data may include a risk factor of a user, indicative of a level of risk associated with a particular user to exhibit risk motions patterns, such as to fall, to have a medical incident (e.g. seizure, stroke, heart attack, cardiac arrest, etc.) or the like. Risk factors may be determined based on age, disability level, medical history, genetic predisposition, previous risks materialising or the like. Risk factors may be quantified as an inactivity time metric. Risk factors may be manually inputted after calculation by a person or determined by the processing unit of the usage monitoring system based on other user data. In one embodiment, each living zone may be associated with a particular risk factor.

[0040] When comparing the real time activity usage pattern to the pre-recorded usage patterns, the processing unit may incorporate a risk factor associated with the user.

[0041] The user data may further include a user acceptable risk factor, indicative of a level of risk assumed by a particular user on registration on the usage monitoring system. In one embodiment, a user acceptable risk factor may be 3, where a user and/or the user's next of kin has accepted a 3 hour delay between detection of a risk motion pattern and activation of the alarm.

[0042] The responder data may include any one or combination of: a responder name, a responder identifier, a responder contact number, a responder pager number, a secondary responder, or the like.

[0043] The usage monitoring system may include a responder interface operable to allow responders access to the usage monitoring system. In particular, the responder interface may provide a remote interface forming part of the usage monitoring system, through which responders can access motions recognised

upon generation of an alarm. The remote interface may be in the form of any one or more of: a web interface, an application programming interface (API) or the like. Advantageously, by including unidentified motion patterns in the risk match and as a trigger for the alarm, and/or including real time motion data in the alarm notification, responders can evaluate the motion of the user to determine a true risk.

[0044] The responder interface may be further operable to receive user data for registration of new users and for the updating of user data of existing users.

[0045] The remote interface provided by the responder interface may categorise the motions patterns into indicators of: user activity, living zone activity, sleep activity, domestic activity, meal activity, and the like. The remote interface may further include indicators of climate, notifications, system operations and the like.

[0046] The usage monitoring system may include an external communications interface which is operable to wirelessly interface with a wearable biometric monitoring device of a user to obtain real time biometric medical data. The biometric monitoring device may be operable to provide real time biometric medical data to the processor to determine whether a risk match is obtained. Real time biometric medical data may include heart rate, perspiration rate, oxygen level, elevation data, or the like.

[0047] The processing unit may receive the digital detection indication(s) from the sensor installation via a wired connection or a wireless connection. The wireless connection may include over a wireless network protocol such as Wireless Fidelity (Wi-Fi), Bluetooth or the like.

[0048] The usage monitoring system may include sensor installations installed in living zones of different users, such that a responder may monitor a plurality of users in a single

care facility. In this embodiment, the usage monitoring system may include a dashboard assembler integrated with the processing unit, operable to generate a real time dashboard of activity overviews for the plurality of users.

[0049] According to another aspect of the invention, there is provided a method of monitoring usage of at least one living zone to identify risks, the method comprising the steps of:

providing a usage monitoring system, as described above, with the sensor installation installed in at least one living zone of at least one user;

receiving real time motion data and usage data from the sensor installation onto the processing unit;

synthesising the real time motion data and the usage data from the sensor installation with the usage recognition module to form a real time activity usage pattern of said user;

comparing the real time activity usage pattern to the pre-recorded usage patterns in the usage identification library; and

activating an alarm module integrated with the processing unit if a risk match is obtained between the real time activity usage pattern and the pre-recorded usage patterns of that particular user.

[0050] The method may include a prior step of registering users.

[0051] The method may include a prior step of populating the usage identification library with pre-recorded usage patterns unique to the user by machine learning implementations. In particular, the processing unit may receive real time motion data from the sensor installation over a predefined period of normal activity. In one embodiment, the predefined period may be five (5) days.

[0052] The method may include an intermediate step of bucketing the real time motion data and the usage data after the step of receiving the real time motion data and the usage data.

In particular, the method may include bucketing the real time motion data and the usage data into 15-minute intervals. In this embodiment, each individual 15-minute interval is compared to the pre-recorded usage patterns in the usage identification library.

[0053] The step of comparing the real time motion data and the usage data to the pre-recorded usage patterns may include the usage recognition module receiving any one or more of the following: specific living zone(s), specific day, specific time, a zone risk factor, a time risk factor, a user acceptable risk factor, and the like.

[0054] The step of comparing the real time motion data and the usage data to the pre-recorded usage patterns may include incorporating a standard deviation factor to compensate for predetermined allowable variation in the normal motion patterns and the usage patterns. The standard deviation factor may thus be determined by previous deviations in normal motion patterns and usage patterns which were deemed allowable by a responder or by the processing unit of the usage monitoring system.

[0055] The method may include an intermediary step of validating a comparison of data when a risk match is obtained, prior to the step of activating an alarm module, in order to reduce occurrence of false positives. In one embodiment, the risk match obtained from the usage recognition module may be validated against a data structure store of sensor states and household states. In another embodiment, the pre-recorded (i.e. normal) usage pattern and the real time activity usage pattern may be analysed by a third party to validate the risk match.

[0056] The alarm module may be operable to dispatch an alarm notification to a responder when a risk match is validated.

[0057] The alarm module may be further operable to generate at least one visual aid which illustrates the pre-recorded usage pattern (i.e. a normal or expected motion pattern) and the real

time activity usage pattern (i.e. a risk motion pattern detected which is typically a deviation from the expected motion pattern). The alarm module may be operable to dispatch an alarm notification containing the at least one visual aid such that a responder can make a visual comparison of data.

[0058] The alarm module may be operable to reset to a normal mode upon the risk match indicating a return to a normal or expected motion pattern.

[0059] The step of synthesising the real time motion data and the usage data from the sensor installation with the usage recognition module to form a real time activity usage pattern may comprise such synthesis for a plurality of users in the at least one living zone.

[0060] According to a further aspect of the invention there is provided a usage monitoring system and a method of monitoring usage of at least one living zone, substantially as herein described and/or illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0061] Further features of the present invention are more fully described in the following description of several non-limiting embodiments thereof. This description is included solely for the purposes of exemplifying the present invention. It should not be understood as a restriction on the broad summary, disclosure or description of the invention as set out above. The description will be made with reference to the accompanying drawings in which:

Figure 1 shows a diagrammatic representation of a usage monitoring system, in accordance with one aspect of the invention;

Figure 2 shows a series of application programming interface (API) tabs on a mobile device which provides the remote

interface of the usage monitoring system shown in Figure 1, which responders can monitor, particularly when a risk match is obtained;

Figure 3 shows a functional diagrammatic representation of a usage monitoring system, in accordance with another embodiment thereof;

Figure 4 shows a flow-diagram of a method of monitoring usage in at least one living zone to identify risks in accordance with another aspect of the invention; and

Figure 5 shows a graphical representation of an example of user activity in a zoned residence or living space having a plurality of users monitored by the usage monitoring system.

DETAILED DESCRIPTION OF EMBODIMENTS

[0062] Further features of the present invention are more fully described in the following description of several non-limiting embodiments thereof. This description is included solely for the purposes of exemplifying the present invention to the skilled addressee. It should not be understood as a restriction on the broad summary, disclosure or description of the invention as set out above.

[0063] In the figures, incorporated to illustrate features of the example embodiment or embodiments, like reference numerals are used to identify like parts throughout. Additionally, features, mechanisms and aspects well-known and understood in the art will not be described in detail, as such features, mechanisms and aspects will be within the understanding of the skilled addressee.

[0064] Additionally, the accompanying figures do not represent engineering or design drawings, but provide a functional overview of the invention only. As a result, features

and practical construction details required for various embodiments may not be indicated in each figure, but such construction requirements will be within the understanding of the skilled addressee.

[0065] With reference to the Figures, reference numeral 10 is used throughout this specification to indicate, generally, a usage monitoring system of the invention. Figure 1 shows a broad embodiment of the usage monitoring system (10) together with the various functional and non-functional parts thereof.

[0066] The usage monitoring system (10) includes a sensor installation (12) installable in at least one living zone (14) of a user (16). The sensor installation (12) is operable to capture real time motion data and usage data in the at least one living zone (14). Importantly, as described in more detail below, the sensor installation (12) captures such motion data and usage data in a nonintrusive manner, i.e. senses a presence or actions of a user in a manner which does not encroach on the privacy of the user, such as having to wear a wearable or via photography.

[0067] The usage monitoring system (10) includes a processing unit (18) in communication with the sensor installation (12). The processing unit (18) is operable to receive the real time motion data and the usage data from the sensor installation (12).

[0068] The usage monitoring system (10) includes a usage recognition module (20) integrated with the processing unit (18). The usage recognition module (20) has access to a usage identification library (22) populated with pre-recorded usage patterns. The usage recognition module (20) is specifically operable to

- synthesise the real time motion data and the usage data captured by the sensor installation (12) into a real time activity usage pattern,

- compare the real time activity usage pattern to the pre-recorded usage patterns in the usage identification library (22), and
- activate an alarm module/incident validator (24) if a risk match is obtained between the real time activity usage pattern and the pre-recorded usage patterns.

[0069] It is to be appreciated that reference herein to 'real time' is to be understood as meaning an instance of time that may include a delay typically resulting from processing, calculation and/or transmission times inherent in computer processing systems. These transmission and calculations times, albeit of generally small duration, do introduce some delay, i.e. typically less than a second or within milliseconds, but an output or action is performed or provided in perceived real time.

[0070] The alarm module/Incident validator (24) is further included in the usage monitoring system (10), integrated with the processing unit (18). The alarm module/Incident validator (24) is activated by the usage recognition module (20) when a risk match is obtained.

[0071] In this particular example, the at least one living zone (14) comprises two living zones (14.1, 14.2) of the user (16). The user (16) is intended to be an elderly person, a disabled person or the like, although further at-risk users potentially requiring healthcare - or emergency services are envisaged.

[0072] To ensure nonintrusive sensing, the sensor installation (12) generally includes passive infrared sensors (12.1, 12.2) and ultrasonic motion sensors (12.3, 12.4) which are operable to capture the real time motion data. It is to be appreciated, however, that the usage monitoring system (10) is sensor-agnostic and that any one, or combination of, the following movement detection sensors are workable in other

embodiments: microwave sensors, passive infrared sensors, area reflective sensors, ultrasonic motion sensors, movement sensors and presence sensors. All such sensors are generally nonintrusive.

[0073] The sensor installation (12) is operable to detect movement in the at least one living zone (14) by means of passive infrared sensor (12.1, 12.2) and an ultrasonic sensor (12.3, 12.4) to provide a digital "detection"/"no-detection" indication, i.e. nonintrusive. The real time motion data captured by the installation (12) is thus in the form of a digital detection indication over a period of time for normal usage of the at least one living zone (14). The real time motion data or digital detection indication is timestamped, allowing for distinctions between important timeframes during the day and/or night, as well as on specific days of the week.

[0074] Although not specifically shown in this example, the usage monitoring system (10) includes one or more auxiliary sensors operable to augment the real time motion data processing by the processing unit (18) by providing the usage data. The sensor installation (12) can thus further detect usage (in addition to motion) in the at least one living zone (14) by means of the one or more auxiliary sensors (or usage sensors) which provide a digital "use"/"no use" indication as the usage data. The one or more auxiliary sensors can include power sensors integrated with devices (e.g. television, stove/oven, microwave) to update the processing unit (18) on usage of those devices, as well as door sensors installed on one or more doors (e.g. front door, bathroom door, garage door) to update the processing unit (28) on usage of those doors, and open-close sensors installed on cupboard doors (e.g. pantry door), appliances or the like, to update the processing unit on usage. These auxiliary sensors are particularly useful in relaying usage data to the processing unit (18) which allows for the determination of normal motion patterns. Deviations in normal motion patterns can, in these

instances, indicate other hazards (i.e. not only falls or injuries), such as changes in meal habits, self-isolation habits, etc. The one or more auxiliary sensors can also include temperature sensors installed in the at least one living zone (14), operable to update the processing unit (18) on real time temperatures in each living zone (14), which can be indicative of a hazard.

[0075] Also not specifically shown in this example, the sensor installation (12) can include a cloud-based Internet of Things (IoT) hub operable to receive and compile the real time motion data and the usage data from the various sensor types (12.1, 12.2, 12.3, 12.4) and auxiliary sensors. The IoT hub is further operable to monitor the battery life and connection status of the sensors (12), auxiliary sensors and an optional wearable device (40), such that the processing unit (18) can immediately notify a responder of an inoperative component within the at least one living zone (14).

[0076] The processing unit (18) is a central processing unit which is remote from the sensor installation (12) and the at least one living zone (14). The processing unit (18) performs operations stipulated by the modules integrated therewith, including the usage recognition module (20) and the alarm module (24). In this example, the processing unit (18) receives the digital detection indication(s) from the sensor installation (12) wirelessly, over a wireless network protocol - Wireless Fidelity (Wi-Fi).

[0077] The usage identification library (22) is in the form of a database of the pre-recorded usage patterns over a period of time for the at least one living zone (14). More specifically, the usage identification library (22) is populated with pre-recorded usage patterns for normal usage of the at least one living zone (14). The usage identification library (22) is populated by means of a combination of: manually defined data patterns, algorithmically defined data patterns, and in an

automated fashion by machine learning implementations. The machine learning implementations ensure the system (10) is optimised for the unique motions and usage of each user (16).

[0078] The pre-recorded usage patterns specifically include motion patterns, usage patterns, durations, time trends and day trends. The motion patterns in this example include normal motion patterns, risk motion patterns, unidentified motion patterns, and exceptional motion patterns operatively to define exceptions to normal motion patterns, associated with user activity habits, user bathroom habits, user sleep habits, user meal habits and user social habits.

[0079] The normal motion patterns are motion patterns which were previously recognisable as normal, day-to-day or occasional motions of users (16). In addition, the normal motion patterns include motion patterns which are unique to the user (16). Normal motion patterns can include, for example, normal night time activity. If a particular user is a restless sleeper, the normal night time activity will include the user's unique restlessness motion patterns.

[0080] The risk motion patterns are motion patterns which were previously recognised as deviations from the normal motion patterns, motion patterns which were previously recognised as restricted movement patterns, and otherwise atypical motion patterns of the user (16). Examples of risk motion patterns include: Decreased movement in a living zone, lack of movement in a living zone, unexpected movement in a particular living zone, a user detected as spending an atypical amount of time in a living zone, or a user detected as remaining in a living zone for an atypical amount of time. More specific examples of risk motion patterns include: Movement in a living zone and sudden no further movement in that living zone; and movement in a living zone and sudden limited movement in that living zone but no other living zones.

[0081] The unidentified motion patterns are motion patterns which were previously detected but could not be successfully identified or categorised, as either normal motion patterns, risk motion patterns or exceptional motion patterns. It is to be appreciated that further processing can reclassify an unidentified motion pattern as a normal motion pattern, a risk motion pattern or an exceptional motion pattern, as the case may be.

[0082] The pre-recorded usage patterns in the usage identification library (22) are specifically grouped according to specific living zone(s) (14) of the user (16). These living zones (14) are selected from: bedroom, bathroom, kitchen, lounge, and garage. It is appreciable that the pre-recorded usage patterns and timelines of each zone (14) will be distinct from the other zones, based on the usage of respective zones (14) by users (16). Thus, each living zone has a zone risk factor associated therewith, which can be predefined based on the type of living zone or can be determined by the usage monitoring system based on any content of the living zone.

[0083] The pre-recorded usage patterns in the usage identification library (22) are also grouped according to specific days of the week, and specific times within each day. This allows the usage recognition module (20) to operably consider any one or more of the following when comparing the real time activity pattern to pre-recorded usage patterns: specific living zone(s), specific day, specific time, and risk factors associated with any one or more of the aforementioned.

[0084] In this example, the usage patterns which are detected by the one or more auxiliary sensors (or usage sensors) include any one or more of: door usage patterns, device usage patterns, appliance usage patterns and cupboard usage patterns.

[0085] The risk match, which is obtained between the real time activity usage pattern and the pre-recorded usage patterns

by the usage recognition module (20), includes: at least a partial match between the real time activity usage pattern and a risk motion pattern (with full matches being included in this category); and at least a partial match between the real time activity usage pattern and an unidentified motion pattern. As such, if a match between the real time activity usage pattern and a normal motion pattern is obtained, no risk match is obtained, and hence the alarm module (24) is not activated. Other risk factors and data are included in determining whether a risk match is obtained, such being received by the usage recognition module, including the zone risk factor, the time risk factor, the user acceptable risk factor etc.

[0086] The usage recognition module (20) is operable to recognise an onset of a risk motion pattern and obtain a risk match to activate the alarm module (24) at an early stage. Advantageously, this allows responders to react proactively prior to a risk materialising if possible.

[0087] The usage monitoring system (10) further includes a database (26) in the form of a cloud-based database which is accessible via a gateway (not shown). The database (26) stores the usage identification library (22) and is accessible by the usage recognition module (20) through the gateway.

[0088] The database (26) further stores user data (28) and responder data (30), and is accessible by the alarm module (24) through the gateway. The user data (28) includes: a user name, a user identifier, a user address, a user emergency contact, a user next of kin, a user do-not-resuscitate (DNR) order status, a user disability level, a user health risk(s), a user medical history, a user genetic predisposition(s), a user acceptable risk factor, user-associated documents and similar user details necessitated by such a system (10). In particular, the user data (28) includes a risk factor of a user, which is indicative of a level of risk associated with a particular user to exhibit risk motions patterns, such as to fall or to have a medical incident

(e.g. seizure, stroke, heart attack, cardiac arrest, etc.). This risk factor is determined based on any one or combination of: age, disability level, medical history, genetic predisposition and a previous risk(s) materialising, and is quantified an inactivity time metric. In this example, the risk factor of each user is manually calculated by a person as the inactivity time metric and inputted as user data (28). It is to be appreciated that the risk factor of a user would typically increase following each risk realised (i.e. after each fall). In other examples however, it is envisaged that this risk factor can be determined by the processing unit (18) based on the other user data (28). Regardless of how inputted, the processing unit (18) will incorporate a risk factor associated with a user when comparing the real time motion data to pre-recorded usage patterns.

[0089] The user data (28) further includes a user acceptable risk factor, indicative of a level of risk assumed by a particular user on registration on the usage monitoring system (10). In this example, the user acceptable risk factor can be either 3 or 4, where a user and/or the user's next of kin has accepted either a 3 or 4 hour delay between detection of a risk motion pattern and activation of the alarm.

[0090] The responder data (30) includes: a responder name, a responder identifier, a responder contact number, a responder pager number, a secondary responder, and similar responder details necessitated by such a system (10). The responder can be a home supervisor, a nurse, a medic or similar responder to a risk scenario such as a fall. The responder can also include family members of the user, particularly where the usage monitoring system (10) is installed in a private residence. Family responders can be notified of periods of decreased user activity or user self-isolation, such that family appropriate responses can address these risks.

[0091] The alarm module (24) is operable to dispatch an alarm notification to a responder, using the responder data (30) on

the database (26), when a risk match is obtained and validated. The alarm notification can be in the form of any one or more of: a push notification, an email notification and a short message service (SMS). The alarm notification specifically includes the user data (28) of the particular user at risk. The alarm notification further includes the risk match and the real time motion data of the user (16), such that a responder can evaluate a risk. Ideally, the alarm notification is dispatched timeously to ensure that not more than three hours lapses between an incident and a response by the responder - minimising harm to the user and reducing the risk of avoidable health implications.

[0092] To achieve this, the usage monitoring system (10) includes a responder interface (32) which is operable to allow responders access to the usage monitoring system (10). The responder interface (32) provides a remote interface (34) through which responders can access real time usage activity patterns and pre-recorded usage patterns (specifically, historically) upon generation of an alarm. The remote interface (34) in this example is in the form of an application programming interface (API) on a mobile device. Advantageously, by including unidentified motion patterns in the risk match and as a trigger for the alarm, as well as including the real time motion data of the user (16) in the alarm notification, responders can evaluate the motion of the user (16) to determine a true risk.

[0093] The alarm module (24) is further operable to escalate an alarm notification to a further responder(s) should no response from an initial responder be detected within an acceptable timeframe of 15 minutes. The alarm notification can be escalated timeously before the three-hour time-lapse target is reached.

[0094] The responder interface (32) is further operable to receive user data (28) for registration of new users and for the updating of user data (28) of existing users. This can be

received or updated through the remote interface (34) or another user interface (36) associated with a user (16).

[0095] In one embodiment, the usage monitoring system (10) may further include an external communications interface (38) which is operable to wirelessly interface with an optional wearable biometric monitoring device (40) of a user (16) to obtain real time biometric medical data. The wearable biometric monitoring device (40) provides real time biometric medical data to the processor (18) to assist in the determination of whether a risk match is obtained. Real time biometric medical data can include heart rate, perspiration rate, oxygen level, elevation data, and other data specific to the user (16) wearing the device (40).

[0096] Specific examples of scenarios and factors considered are discussed below.

[0097] Example 1: Movement of a user is detected in a bedroom. Movement of the user into a bathroom is detected. A period of time, specifically one hour, passes with no further movement of the user detected in the bathroom or the bedroom. Although no specific risk motion pattern was identified, nor was an unidentified motion pattern, a risk match would likely be obtained based on the usage pattern and timestamps alone. The motion pattern is recognised as a risk motion pattern and the alarm module activated.

[0098] Example 2: Movement of a user is detected in a bedroom. No further movement of the user is detected. The timestamps on the real time motion data indicate that it is evening. The processing unit determines that the user is likely sleeping and no risk match is obtained. The motion pattern is recognised as a normal motion pattern. If a risk match is obtained, validation of the risk match at the alarm module will invalidate the match and ensure no alarm notification is dispatched.

[0099] Example 3: No movement is detected in a living room after some movement is detected. An auxiliary sensor in the form of a power sensor integrated with a television indicates usage of the television, influencing whether a risk match is obtained by the processing unit. Depending on duration of television use, a risk match may or may not be obtained.

[00100] Examples of the remote interface (34) which is provided by the responder interface (32) of the usage monitoring system (10) are shown in Figure 2. As shown in Figure 2.1, the remote interface (34) specifically categorises the motions patterns into indicators of various activities on the home page. These activities include:

- User activity ("Activity" button in Figure 2.1, see Figure 2.2 for detail), indicating whether the user motion patterns in the at least one living zone are normal motion patterns or risk motion patterns. As motion patterns are grouped according to living zones (14) and days/times in the usage identification library (22), as described above, motion patterns in different living zones and/or on different days can be provided. The overall activity of the user detected by the sensor installation (12) is typically a good indicator of abnormalities/deviations in motion patterns detected. Advantageously, user activity can be used to indicate daily by way of a push notification whether a user is awake each morning at a predefined time (e.g. 10:00).
- Living zone activity ("Presence and Social" button in Figure 2.1), indicating whether or not the user is in the at least one living zone (14) and/or whether any additional persons are detected in the at least one living zone (14). This feature allows responders to monitor appointment attendance, outings, etc.

- Sleep activity ("Sleep" button in Figure 2.1, see Figure 2.4 for detail), indicating various motions detected associated with sleep such as night activity, bathroom visits, total amount of sleep, and arise time. Normal motion patterns (determined historically from previously detected motion patterns unique to the user) and deviations from normal motion patterns are indicated.
- Domestic activity ("Domestic" button in Figure 2.1), indicating use of appliances associated with domestic activities, such as running a washing machine, tumble dryer or dishwasher. Such activities are typically monitored with auxiliary sensors installed on appliances, monitored together with movement sensors and motion patterns.
- Meal activity ("Meals" button in Figure 2.1, see Figure 2.5 for detail), indicating whether a meal event was detected for each meal of each day. Meal events can be detected through matching motion patterns of eating with normal motion patterns, monitored together with auxiliary sensors installed on appliances (e.g. microwave, toaster, stove/oven, refrigerator) and/or on pantry doors.

[00101] The remote interface (34) further includes indicators of:

- Climate ("Climate" button in Figure 2.1, see Figure 2.3 for detail), indicating whether the climate in the at least one living zone (14) is within predefined parameters. Specifically, real time temperatures for each living zone (14) are displayed.
- Notifications ("Notifications" button in Figure 2.1, see Figure 2.6 for detail), indicating whether any specific category of motion pattern requires immediate attention

when a risk match is obtained, as well as notifications related to system operations (e.g. sensor being offline or requiring servicing).

- System operations ("System Health" button in Figure 2.1, see Figure 2.7 for detail), indicating the status of all sensors, auxiliary sensors, the wearable biometric monitoring device, the IoT hub (including battery) or any of the connections.

[00102] In another embodiment of the invention (not shown in the figures), the usage monitoring system (10) include sensor installations installed in living zones of different users in a single care facility. This allows a responder to monitor all of the users in the care facility simultaneously. In this embodiment, the usage monitoring system (10) specifically includes a dashboard assembler which is integrated with the processing unit (18). The dashboard assembler is operable to generate a real time dashboard of activity overviews for the plurality of users, which is communicated to the remote responder interface (32) for display. The dashboard allows the responder to prioritise attendance to highest risk users in order to improve outcomes and optimise staff operations.

[00103] In Figure 3, another, more detailed embodiment of the usage monitoring system (10) is illustrated. This embodiment of the usage monitoring system (10) shares various features with the system (10) shown in Figure 1, as the reference numerals indicate.

[00104] The usage monitoring system (10) is operable to detect and monitor a user's (16) movement and activity within at least one living zone (14), specifically to identify risk motions or patterns of use by the user (16). In this example, the system (10) includes a sensor installation (12) comprised of motion sensors that are passive infrared sensors installed in the at least one living zone (14) and usage sensors that are power

sensors integrated with devices in the at least one living zone (14). The sensor installation (12) is operable to capture real time motion data or telemetry data, as well as usage data, which it compiles at an Internet of Things (IoT) hub, that might be hosted in the cloud. The usage data is in the form of time-stamped digital "detection"/"no-detection" indications and time-stamped digital "use"/"no-use" indications. The IoT hub includes an onsite battery.

[00105] The usage monitoring system (10) also includes a processing unit (18) comprised of multiple components, as shown. The processing unit (18) is in wireless communication with the sensor installation (12) via the IoT hub to receive the real time motion (or telemetry data) and the usage data. The processing unit (18) specifically includes a usage recognition module/streaming analytics module (20), which provides streaming analytics. The usage recognition module (20) has access to a usage identification library (22) which is populated with pre-recorded usage patterns, as previously described, which are unique to the user. These pre-recorded usage patterns form reference data which is used for comparisons, the reference data in this example being stored as unstructured data on the cloud in Blob storage. The reference data provides a streaming analytics reference, which is updated every 15 minutes. An example of the reference data format is as follows:

```
"householdId":      "25ce3fb9-5ae4-2fd4-246a-dfa7e06a0fda",  
"link": 1,  
  "friendlyname": "simulated2-ctwjs0",  
  "sleepingStart": 14,  
  "sleepingFinish": 22
```

[00106] The usage recognition module/streaming analytics module (20) is operable to:

- synthesise the real time motion (or telemetry data) and the usage data captured by the sensor installation (12) into a real time activity usage pattern,
- compare the real time activity usage pattern to the pre-recorded usage patterns or reference data in the usage identification library (22) via Blob storage, and
- activate an alarm module (24) if a risk match is obtained between the real time activity usage pattern and the pre-recorded usage patterns.

[00107] The above steps include streaming alarms/incidents in an incident detection que and scheduling them in an incident event scheduler, where after the incidents are queued in an incident validation que.

[00108] In one scenario, for example, the usage recognition module (20) will obtain a risk match where there is a one-hour period of no movement (represented by sensor inactivity) in a living zone (or activity room), after movement was previously detected in that living zone (through sensor activity or sensor event).

[00109] The alarm module (24) is further included in the usage monitoring system (10), integrated with the processing unit (18). The alarm module (24) is activated by the usage recognition module (20) when a risk match is obtained, however further steps of validation are undertaken before an alarm notification is dispatched (described below).

[00110] The usage monitoring system (10) further includes a cloud-based database (26), which stores the usage identification library (22) accessible by the usage recognition module (20), as well as user data (28) and responder data (30) accessible by the alarm module (24). The database (26) is accessible through gateways.

[00111] The alarm module (24) is operable to validate a risk match obtained (or incident event detected) from the usage recognition module (20). It performs this function by comparing risk matches or incidents with a data structure store (50). In this example, the data structure store is in-memory Redis (remote dictionary server) and data structure stores for sensor states (50.1) and household states (50.2) are used. Time stamps are also validated for comprehensiveness.

[00112] When a risk match or incident is obtained and validated with sensor and household states, the alarm module (24) dispatches an alarm notification to a responder, using the responder data (30) on the database (26). To achieve this, the processing unit (18) includes a responder interface/service bus (32) through which responders receive the alarm notification (34) and can access the real time activity usage pattern against the pre-recorded usage patterns upon generation of an alarm. The alarm notification in this embodiment includes the relevant location or household, and the relevant living zone or room.

[00113] In Figure 4, reference numeral 100 refers, generally, to a method of monitoring usage in at least one living zone to identify risks. The method (100) starts at 102.

[00114] At 104, the flow-diagram indicates that the method (100) is dependent on the initial step of providing a usage monitoring system (10). The usage monitoring system (10) is as described above, with the sensor installation (12), comprised of motion sensors and usage sensors, installed in at least one living zone (14) of the user (16). This step includes registering users, both users (16) and responders, by receiving user data (28) and responder data (30) onto the usage monitoring system (10) and saving same in the remote database (26). As each user (16) is registered, the method (100) includes populating the usage identification library (22) with pre-recorded usage patterns unique to the specific user (16) by machine learning implementations. The library (22) is populated by the processing

unit (18) receiving real time motion data from the sensor installation (12) over a predefined period of five days of normal activity. This provides the normal motion patterns unique to the user (16) against which further, real time motion data and usage can be compared.

[00115] At 106, the method (100) includes the step of receiving real time motion data and usage data from the sensor installation (12) onto the processing unit (18). As previously indicated, the motion sensors include passive infrared sensors (12.1, 12.2) and/or ultrasonic sensors (12.3, 12.4) to provide a digital "detection"/"no-detection" indication, the real time motion data thus being in the form of a digital detection indication over a period of time for normal usage of the at least one living zone (14). The usage sensors include open-close sensors on doors etc. to provide signals associated with doors, appliances, devices, etc.

[00116] It is to be appreciated that at this stage (i.e. after the step of receiving the real time motion data), in order to reduce computing, the method (100) can include an intermediate step of bucketing the real time motion data and the usage data. In one example, the method (100) can include bucketing the real time motion data and usage data into 15-minute intervals, such that each individual 15-minute interval can be further processed.

[00117] At 108, the method (100) includes the step of synthesizing the real time motion data and the usage data from the sensor installation with the usage recognition module to form a real time activity usage pattern. In this example, each 15-minute interval is synthesized to a single real time activity usage pattern which can be compared to the pre-recorded usage patterns in the usage identification library (22).

[00118] At 110, the method (100) includes the step of comparing the real time activity usage pattern to pre-recorded usage

patterns in the usage identification library (22). Each 15-minute interval is compared individually to ensure timely detection of risks. This step of comparing the real time activity usage pattern to the pre-recorded usage patterns (110) importantly includes incorporating a standard deviation factor to compensate for predetermined allowable variation in normal motion patterns and normal usage patterns. The standard deviation factor is determined by previous deviations in normal motion patterns and/or usage patterns which were deemed allowable by a responder or by the processing unit (18) of the usage monitoring system (10).

[00119] Although not illustrated in this example, in another embodiment the method (100) includes an intermediary step of validating a comparison of data when a risk match is obtained, prior to the step of activating an alarm module (112), in order to reduce occurrence of false positives. In particular, the risk match is validated by the alarm module (112) against a data structure store, in the form of an in-memory remote dictionary server having sensor states and household states. Alternatively, the normal motion pattern and the risk motion pattern can be analysed by a third party to validate the risk match before the alarm module is activated.

[00120] If a risk match is obtained between the real time activity usage pattern and the pre-recorded usage patterns, the method (100) includes the step at 112 of activating an alarm module (24) integrated with the processing unit (18). The alarm module (24) dispatches an alarm notification via the responder interface (32) to the remote interface (34) on a mobile device of the responder.

[00121] The alarm module (24) is also operable to generate at least one visual aid, such as a line graph (not shown), which illustrates the pre-recorded usage pattern (i.e. the normal motion pattern or an expected motion pattern) and real time

activity usage pattern (i.e. the risk motion pattern detected or a deviation from the expected motion pattern).

[00122] The alarm notification includes sufficient data, as described, to allow a responder to assess risk in the situation. In particular, the alarm notification includes the at least one visual aid such that the responder can make a visual comparison of data to assess risk. If no risk match is obtained, the method (100) reiterates from step 106. The method (100) ends at reference numeral 114.

[00123] With reference to Figure 6, in a further embodiment, particularly suited to monitoring a plurality of users (16) in a single living zone (14), such as in shared accommodation, nursing homes, etc., the usage monitoring system (10) as described herein may be configured to configure the usage identification library (22) such that each room (14.1) and (14.2) comprises a unique identification in the living space (14) to be monitored, such that the living space is divided into individually-monitored zones. In the example of Figure 6, this is exemplified as personal living zones for 'Sharon', 'Maryellen', 'Meg' and a common area, as shown. Such a zoned living space is typically stored in the usage identification library (22), along with individual pre-recorded usage patterns unique to each individual user.

[00124] Individual sensors of the sensor installation (12) are then allocated to each defined room or zone. For example, Bedroom 1 may have the following typical sensors associated with it: Bedroom1 motion, Bedroom1 Door, Bedroom Duress Button 1, etc. Similarly, an associated ensuite bathroom may have Ensuite1 Motion Sensor associated with it. Bedroom 1 and Ensuite 1 are associated with Personal Living Zone 1. Common Area Zone will contain rooms such a living room, kitchen, laundry etc, and each will have sensors associated with these specific rooms. Residence exit doors are also associated with one or more common areas.

[00125] Each of these sensors have a unique identifier that is sent along with a timestamp and related status telemetry (e.g. on/off, open/close, 24% presence, etc.). As the data is received in real time, the system (10) as described tags the telemetry data with additional meta data such as Residence Id, Room and Zone based on the stored configuration in the usage identification library (22), e.g. the cloud-based database. The usage recognition (20) module, typically using real time analytics, is then able to process the data in multiple analytic streams based on the zone.

[00126] Any resultant real time events, e.g. duress press, and other real time analytics outputs are then tagged with the associated zone for future processing. The usage recognition (20) module, using temporal analytics, can be configured to iterate through each zone for a given Residence ID creating multiple data sets for defined analytics. Private area zones can also be subject to such process analytics for individual metrics, such as bathroom visits, night-time activity, sleep qty, etc.

[00127] Common area zones can be analysed for additional metrics such as meal preparation, exit door events, common area day and night activity, etc. Analytics or event alerting can be configured per zone, e.g. Marie's personal living space or zone can be set to have door open alerts, whereas Jane's zone does not, requirements depending. Similarly, the system 10 can be configured to track Marie's sleep, but not Jane's, and the like.

[00128] In this manner, the system (10) is configurable to support multiple zones and multi-resident accommodation. The usage identification library (22), typically via a web portal, can be configured to allow for the creation of zones and associating rooms and sensors therewith. Zones can also be named to reflect the identity of the individual active in that particular zone. Reports on user activity can be made 'zone aware' and can be created for a whole residence or for an individual user and/or zone, depending on requirements.

Associated longer-term trends and related trend based analyses and alerting can also be done on a 'per zone' basis, or a 'per user' basis, as required.

[00129] All alerts, notifications or messages can be configured to be 'zone aware', where such notifications are able to inform the recipient of the room and zone that generated the event. In such a manner, zone-specific and user-specific tracking and monitoring can be achieved, along with associated notifications to intended recipients based on such intelligent analytics of nonintrusive monitoring via the sensor installation (12).

[00130] The Applicant is of the opinion that the invention provides a useful usage monitoring system and a method of monitoring usage to proactively identify risks, which presents the advantages of low cost of equipment and installation, ease of setup and less intensive computational requirements as compared to camera-based systems and methods. Furthermore, as no cameras are required for the system, user privacy is respected without compromising risk detection. The usage monitoring system and method allows users (e.g. seniors or disabled persons) to remain living independently whilst ensuring that responders are readily notified in case of abnormal/deviated/unexpected activity. Importantly, the usage monitoring system of the present invention requires no direct photographic data of a person, nor requires a sensor mounted on a person of such user, so that monitoring is done in a nonintrusive manner.

[00131] Optional embodiments of the present invention may also be said to broadly consist in the parts, elements and features referred to or indicated herein, individually or collectively, in any or all combinations of two or more of the parts, elements or features, and wherein specific integers are mentioned herein which have known equivalents in the art to which the invention relates, such known equivalents are deemed to be incorporated herein as if individually set forth. In the example embodiments,

well-known processes, well-known device structures, and well-known technologies are not described in detail, as such will be readily understood by the skilled addressee.

[00132] The use of the terms "a", "an", "said", "the", and/or similar referents in the context of describing various embodiments (especially in the context of the claimed subject matter) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. No language in the specification should be construed as indicating any non-claimed subject matter as essential to the practice of the claimed subject matter.

[00133] It is to be appreciated that reference to "one example" or "an example" of the invention, or similar exemplary language (e.g., "such as") herein, is not made in an exclusive sense. Various substantially and specifically practical and useful exemplary embodiments of the claimed subject matter are described herein, textually and/or graphically, for carrying out the claimed subject matter.

[00134] Accordingly, one example may exemplify certain aspects of the invention, whilst other aspects are exemplified in a different example. These examples are intended to assist the skilled person in performing the invention and are not intended to limit the overall scope of the invention in any way unless the context clearly indicates otherwise. Variations (e.g. modifications and/or enhancements) of one or more embodiments described herein might become apparent to those of ordinary skill in the art upon reading this application. The inventor(s) expects skilled artisans to employ such variations as appropriate, and

the inventor(s) intends for the claimed subject matter to be practiced other than as specifically described herein.

[00135] Any method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

CLAIMS

1. A usage monitoring system comprising:

a sensor installation installable in at least one living zone of a user, the sensor installation operable to capture any one or both of real-time motion data and usage data in the at least one living zone in a nonintrusive manner;

a processing unit in communication with the sensor installation, operable to receive the real time motion data and the usage data from the sensor installation;

a usage recognition module integrated with the processing unit, the usage recognition module having access to a usage identification library populated with pre-recorded usage patterns, the usage recognition module operable to:

- synthesise the real-time motion data and the usage data captured by the sensor installation into a real time activity usage pattern,
- compare the real time activity usage pattern to the pre-recorded usage patterns in the usage identification library, and
- activate an alarm module if a risk match is obtained between the real time activity usage pattern and the pre-recorded usage patterns; and

an alarm module integrated with the processing unit, the alarm module activated by the usage recognition module when a risk match is obtained;

wherein the system is able to monitor personal activity of a user in a nonintrusive manner.

2. The system of claim 1, which includes a database storing at least user data and responder data, the database being accessible by the alarm module.

3. The system of claim 2, in which the database is a cloud-based database accessible through one or more gateways.

4. The system of claim 1, which is sensor-agnostic and in which the sensor installation includes any one or combination of: microwave sensors, passive infrared sensors, area reflective sensors, ultrasonic motion sensors, movement sensors and presence sensors.

5. The system of claim 1, in which the sensor installation is operable to detect movement in the at least one living zone by means of a movement detection sensor to provide a digital "detection"/"no-detection" indication as the real time motion data.

6. The system of claim 1, in which the sensor installation is operable to detect usage of components in the at least one living zone by means of a usage detection sensor to provide a digital "use"/"no-use" indication as the usage data.

7. The system of claim 1, in which the pre-recorded usage patterns are synthesised from digital detection indications of motion and usage over a period of time for normal usage of the at least one living zone.

8. The system of claim 1, in which any one or both of the real time motion data and the usage data is timestamped.

9. The system of claim 1, in which the sensor installation includes an Internet of Things (IoT) hub operable to receive and compile the real time motion data and the usage data from various sensor types.

10. The system of claim 9, in which the IoT hub is cloud-based.

11. The system of claim 1, in which the usage identification library is in the form of a database of pre-recorded usage patterns recognised over a period of time for the at least one living zone.

12. The system of claim 11, in which the usage identification library is populated with pre-recorded usage patterns for normal usage of the at least one living zone by means of any one or more of: manually defined data patterns, algorithmically defined data patterns and in an automated fashion by machine learning implementations.

13. The system of claim 1, in which the pre-recorded usage patterns include motion patterns, usage patterns, durations, time trends and day trends.

14. The system of claim 13, in which the motion patterns include any one or more of: normal motion patterns, risk motion patterns, unidentified motion patterns and exceptional motion patterns, associated with user activity habits, user bathroom habits, user sleep habits, user meal habits and user social habits.

15. The system of claim 14, in which the normal motion patterns include any one or combination of: motion patterns which were previously recognisable as normal, day-to-day or occasional motions of users and motion patterns which are unique to the user.

16. The system of claim 14, in which the risk motion patterns include any one or combination of: motion patterns which were previously recognised as deviations from the normal motion patterns, motion patterns which were previously recognised as restricted movement patterns and otherwise atypical motion patterns of the user.

17. The system of claim 14, in which the risk motion patterns include any one or combination of: decreased movement in a living zone, lack of movement in a living zone, unexpected movement in a particular living zone, a user detected as spending an atypical amount of time in a living zone, a user detected as remaining in a living zone for an atypical amount of time, movement in a living zone and sudden no further movement in that

living zone, and movement in a living zone and sudden limited movement in that living zone but no other living zones.

18. The system of claim 14, in which the unidentified motion patterns include motion patterns which were previously detected but could not be successfully identified or categorised.

19. The system of claim 14, in which the exceptional motion patterns include exceptions to the normal motion patterns.

20. The system of claim 13, in which the usage patterns include any one or more of: door usage patterns, device usage patterns, appliance usage patterns and cupboard usage patterns.

21. The system of claim 1, in which the pre-recorded usage patterns in the usage identification library are grouped according to specific living zone(s) of the user, with each living zone having a zone risk factor associated therewith.

22. The system of claim 21, in which the zone risk factor is any one of: predefined or determined by the usage monitoring system based on any content of the living zone.

23. The system of claim 1, in which the pre-recorded usage patterns in the usage identification library are grouped according to any one or both of: specific days of the week and specific times within a day(s).

24. The system of claim 1, in which the usage recognition module is operable to receive as input any one or more of the following when comparing the real time activity usage pattern to the pre-recorded usage patterns: specific living zone(s), specific day, specific time and risk factors associated with any one or more of the aforementioned.

25. The system of claim 14, in which the risk match comprises any one or both of: at least a partial match between the real time activity usage pattern synthesised and a risk

motion pattern; and at least a partial match between the real time activity usage pattern synthesised and an unidentified motion pattern.

26. The system of claim 14, in which determining whether a risk match is obtained includes the usage recognition module receiving as input any one or more of: a zone risk factor, a time risk factor, and a user acceptable risk factor.

27. The system of claim 1, in which the alarm module is operable to validate a risk match obtained from the usage recognition module.

28. The system of claim 27, in which the alarm module is operable to compare a risk match with a data structure stored in the form of an in-memory remote dictionary server including any one or more of: sensor states, household states and time states.

29. The system of claim 27, in which the alarm module is operable to dispatch an alarm notification to a responder, using responder data on a database, when a risk match is validated.

30. The system of claim 29, in which the alarm notification is in the form of any one or more of: a push notification, an email notification and a short message service (SMS); and includes any one or combination of: user data of the particular user at risk, the risk match, the real time motion data and the usage data.

31. The system of claim 29, in which the alarm module is further operable to escalate an alarm notification to a further responder(s) should no response from an initial responder be detected within an acceptable timeframe.

32. The system of claim 1, which includes one or more auxiliary sensors operable to augment the real time motion data processing by the processing unit, by providing the usage data.

33. The system of claim 32, in which the one or more auxiliary sensors include any one or combination of: one or more power sensors integrated with devices in the at least one living zone to update the processing unit on usage of the devices; one or more door sensors installed on one or more doors in the at least one living zone to update the processing unit on usage of the doors; one or more open-close sensors installed on cupboard doors or appliances, to update the processing unit on usage of the cupboards or appliances; and one or more temperature sensors installed in the at least one living zone, operable to update the processing unit on real time temperatures in each living zone.

34. The system of claim 2, in which the user data includes any one or combination of: a user name, a user identifier, a user address, a user emergency contact, a user next of kin, a user do-not-resuscitate (DNR) order status, a user disability level, a user health risk(s), a user medical history, a user genetic predisposition(s), a user acceptable risk factor and a user-associated document(s).

35. The system of claim 2, in which the user data includes a risk factor of a user, indicative of a level of risk associated with a particular user to exhibit risk motions patterns, based on any one or more of: age, disability level, medical history, genetic predisposition and previous risks materialising.

36. The system of claim 35, in which the risk factor of a user is quantified as an inactivity time metric and is any one of: manually inputted after calculation by a person or determined by the processing unit of the usage monitoring system based on the user data.

37. The system of claim 36, in which each living zone is associated with a particular risk factor for each user, the processing unit receiving the risk factor as input when comparing

the real time activity usage pattern to the pre-recorded usage patterns.

38. The system of claim 2, in which the user data includes a user acceptable risk factor, indicative of a level of risk assumed by a particular user upon registration on the usage monitoring system.

39. The system of claim 38, in which the user acceptable risk factor is three (3), indicating acceptance of a three (3) hour delay between detection of a risk motion pattern and activation of the alarm.

40. The system of claim 2, in which the responder data includes any one or more of: a responder name, a responder identifier, a responder contact number, a responder pager number, a secondary responder and a secondary responder contact number.

41. The system of claim 1, which includes a responder interface operable to allow responders access to the usage monitoring system through a remote interface forming part of the usage monitoring system.

42. The system of claim 41, in which the remote interface is in the form of any one or both of: a web interface and an application programming interface (API).

43. The system of claim 41, in which the remote interface provided by the responder interface categorises the real time activity usage patterns synthesised into indicators of any one or more of: user activity, living zone activity, sleep activity, domestic activity, and meal activity.

44. The system of claim 1, in which the processing unit further receives signals from the sensor installation relating to any one or both of: climate and system operations.

45. The system of claim 41, in which the responder interface is further operable to receive user data for registration of new users and for the updating of user data of existing users.

46. The system of claim 1, which includes an external communications interface operable to wirelessly interface with a wearable biometric monitoring device of a user to receive real time biometric medical data as input to the processing unit to determine whether a risk match is obtained.

47. The system of claim 5 or 6, in which the processing unit receives the digital detection indication(s) from the sensor installation via any one of: a wired connection or a wireless connection including a wireless network protocol selected from Wireless Fidelity (Wi-Fi) and Bluetooth.

48. The system of claim 41, which includes sensor installations installed in living zones of a plurality of users in a single care facility, and a dashboard assembler integrated with the processing unit which is operable to generate a real time dashboard of activity overviews for the plurality of users, communicated to the remote interface for real time review by a responder.

49. A method of monitoring usage of at least one living zone to identify risks, which includes the steps of:

- providing a usage monitoring system, as described above, with the sensor installation installed in at least one living zone of at least one user;

- receiving real time motion data and usage data from the sensor installation onto the processing unit;

- synthesising the real time motion data and the usage data from the sensor installation with the usage recognition module to form a real time activity usage pattern of said user;

- comparing the real time activity usage pattern to the pre-recorded usage patterns in the usage identification library; and

activating an alarm module integrated with the processing unit if a risk match is obtained between the real time activity usage pattern and the pre-recorded usage patterns of that particular user.

50. The method of claim 49, which includes a prior step of registering users.

51. The method of claim 50, which includes a further prior step of populating the usage identification library with pre-recorded usage patterns unique to a registered user by machine learning implementations, specifically by the processing unit receiving real time motion data and usage data from the sensor installation over a predefined period of normal activity.

52. The method of claim 49, which includes an intermediate step of bucketing the real time motion data and the usage data after the step of receiving the real time motion data and the usage data.

53. The method of claim 52, which includes bucketing the real time motion data and the usage data into fifteen (15) minute intervals and comparing each individual fifteen (15) minute interval to the pre-recorded usage patterns in the usage identification library.

54. The method of claim 49, in which the step of comparing the real time motion data and the usage data to the pre-recorded usage patterns includes the usage recognition module receiving any one or more of the following as input: specific living zone(s), specific day, specific time, a zone risk factor, a time risk factor, and a user acceptable risk factor.

55. The method of claim 49, in which the step of comparing the real time activity usage pattern to the pre-recorded usage patterns includes incorporating a standard deviation factor as input to compensate for predetermined allowable variation in the normal motion patterns and the usage patterns.

56. The method of claim 55, in which the standard deviation factor is determined by previous deviations in normal motion patterns and usage patterns which were deemed allowable by any one of: a responder or the processing unit of the usage monitoring system.

57. The method of claim 49, which includes an intermediary step of validating a comparison of data when a risk match is obtained, prior to the step of activating an alarm module, in order to reduce occurrence of false positives.

58. The method of claim 57, in which the risk match obtained from the usage recognition module is validated against a data structure store of sensor states and household states.

59. The method of claim 57, in which the pre-recorded (i.e. normal) usage pattern and the real time activity usage pattern are dispatched to and analysed by a third party to validate the risk match.

60. The method of claim 49, in which the alarm module is operable to dispatch an alarm notification to a responder when a risk match is validated.

61. The method of claim 49, in which the alarm module is operable to generate at least one visual aid which illustrates the pre-recorded (i.e. normal) usage pattern and the real time activity usage pattern (i.e. abnormal) detected, the alarm module dispatching an alarm notification containing the at least one visual aid to a responder.

62. The method of claim 49, which includes de-activating an alarm module if a risk match between the real time activity usage pattern and the pre-recorded usage patterns disappears.

63. The method of claim 49, wherein step of synthesising the real time motion data and the usage data from the sensor installation with the usage recognition module to form a real

time activity usage pattern comprises such syntheses for a plurality of users in the at least one living zone.

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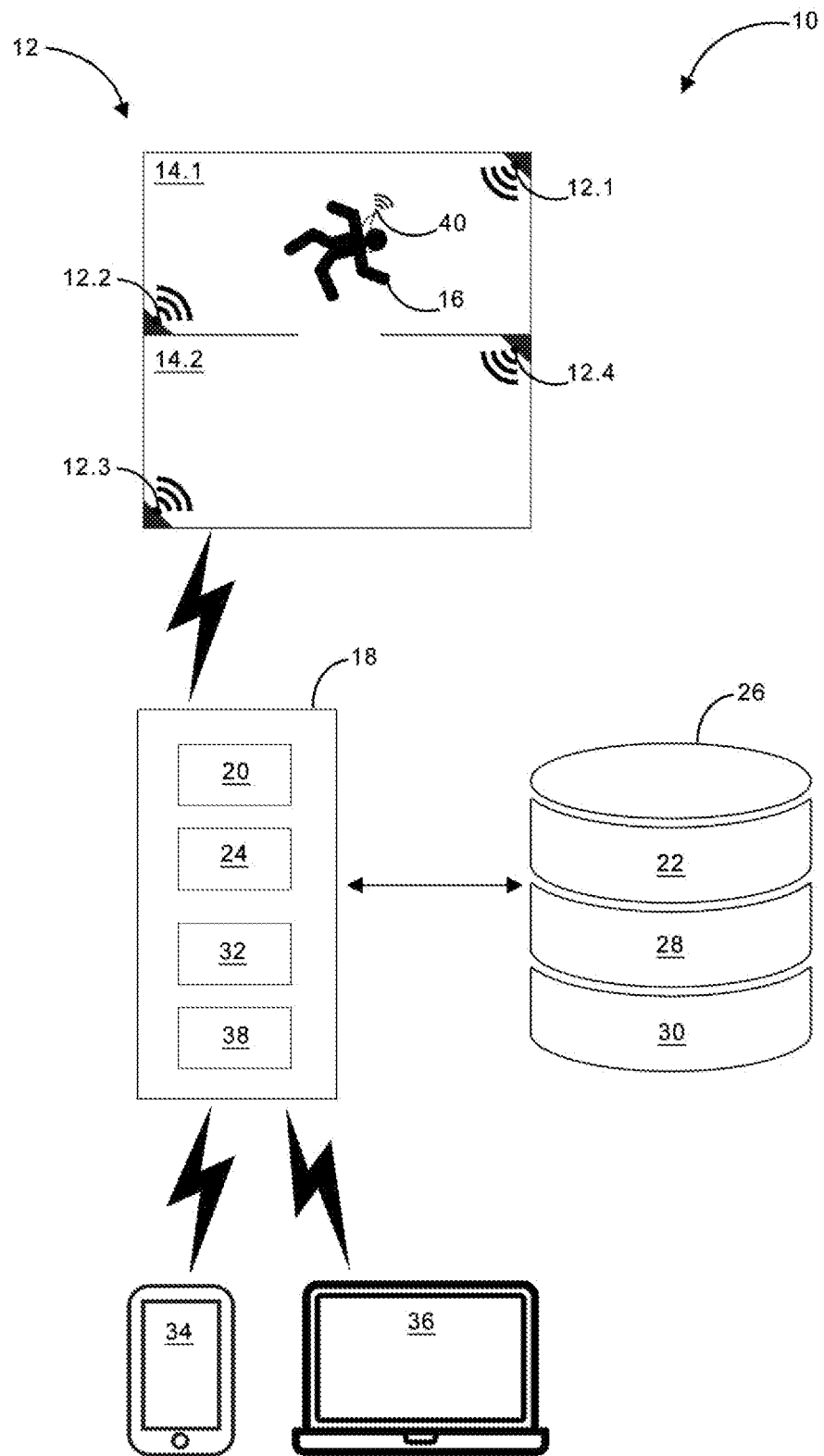


Figure 1



Figure 2.1

Figure 2.2

Figure 2.3

Figure 2.4

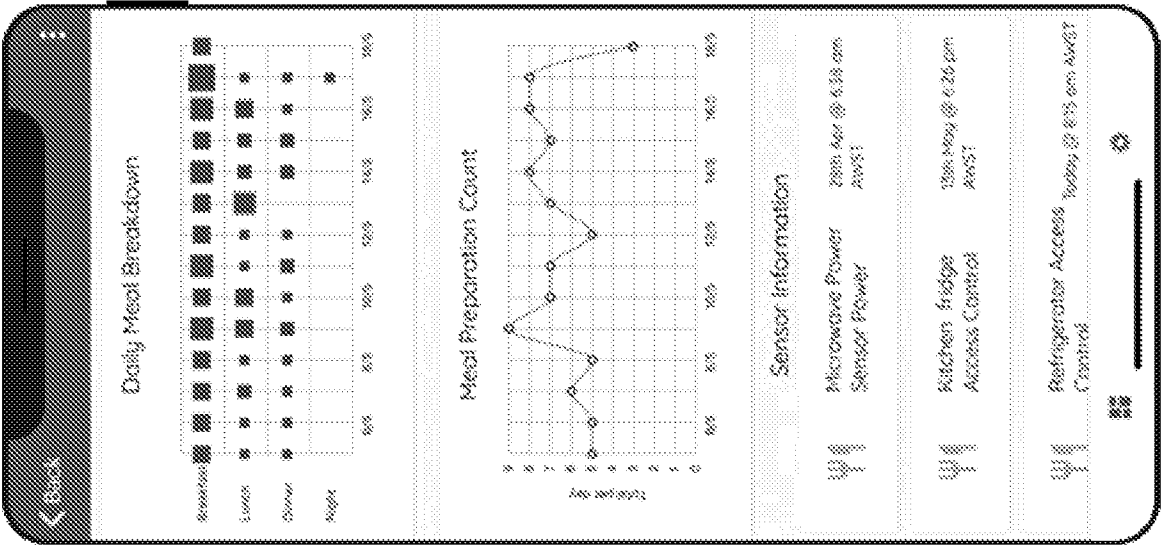


Figure 2.5



Figure 2.6

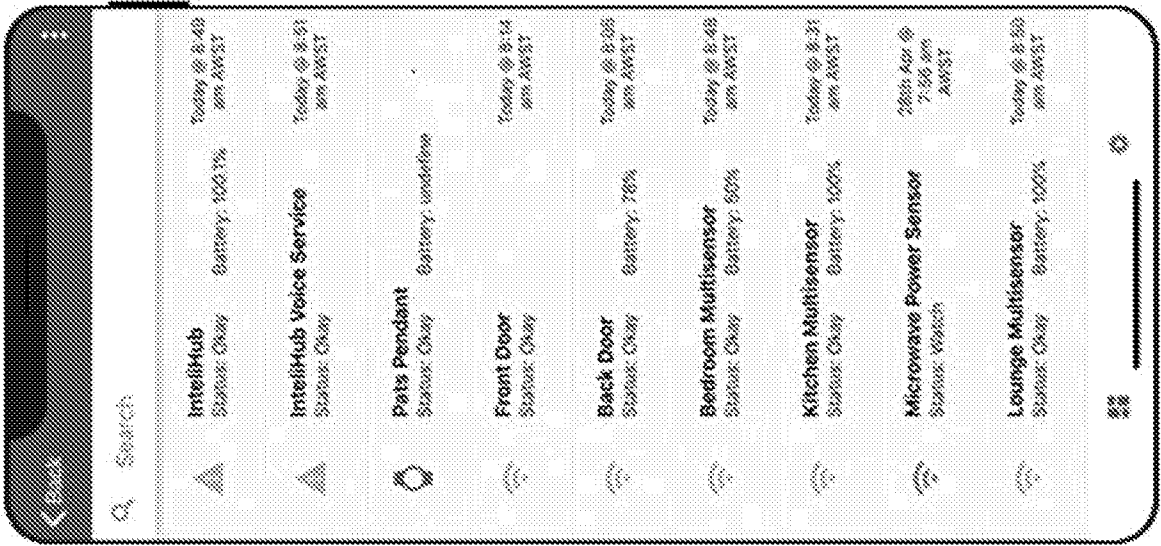


Figure 2.7

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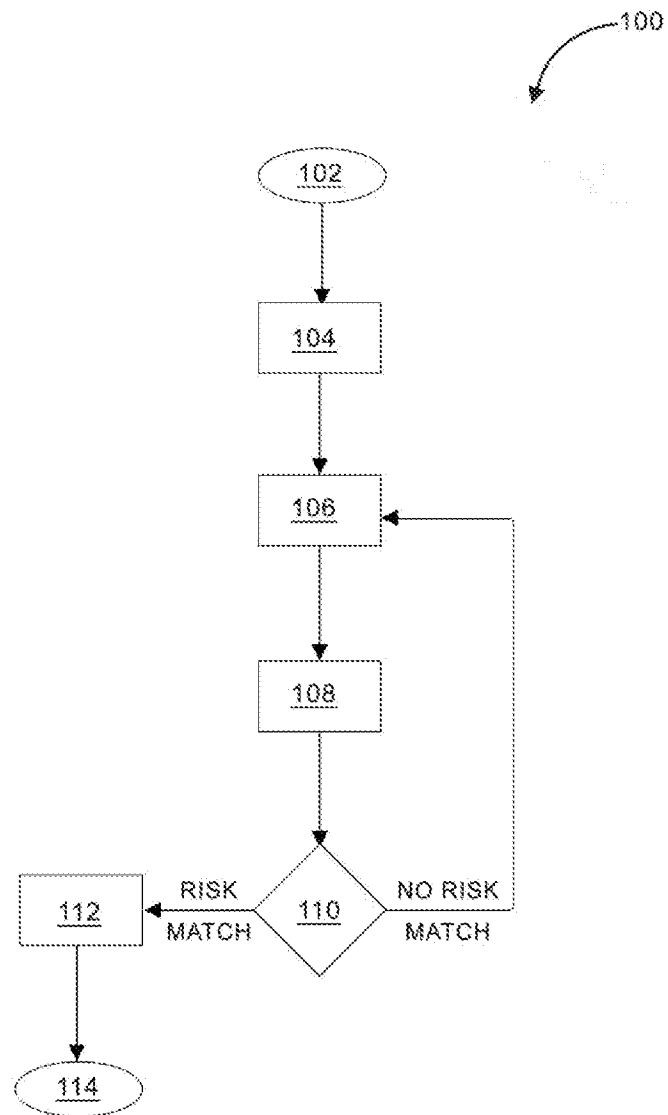


Figure 4

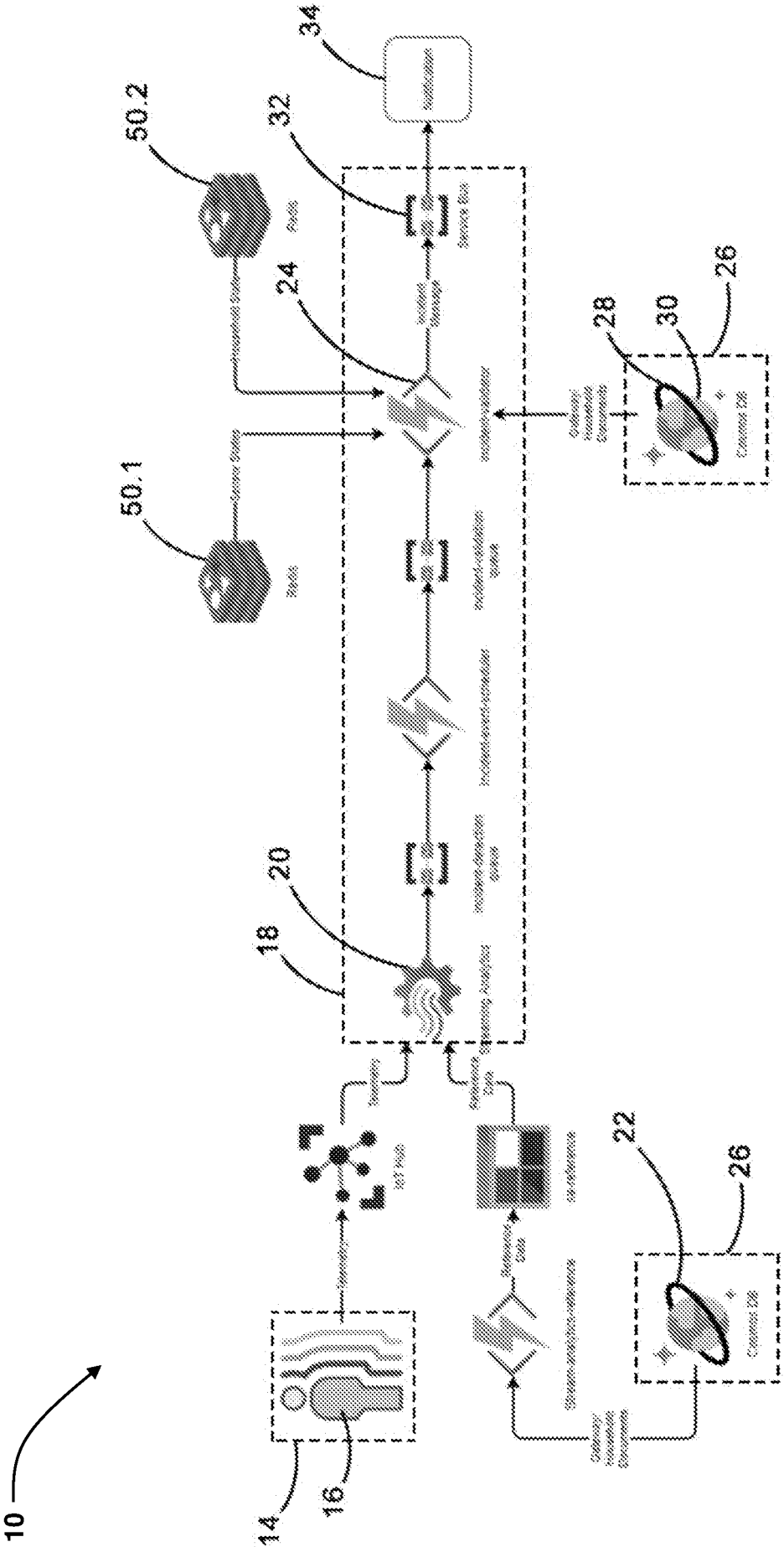


Figure 3

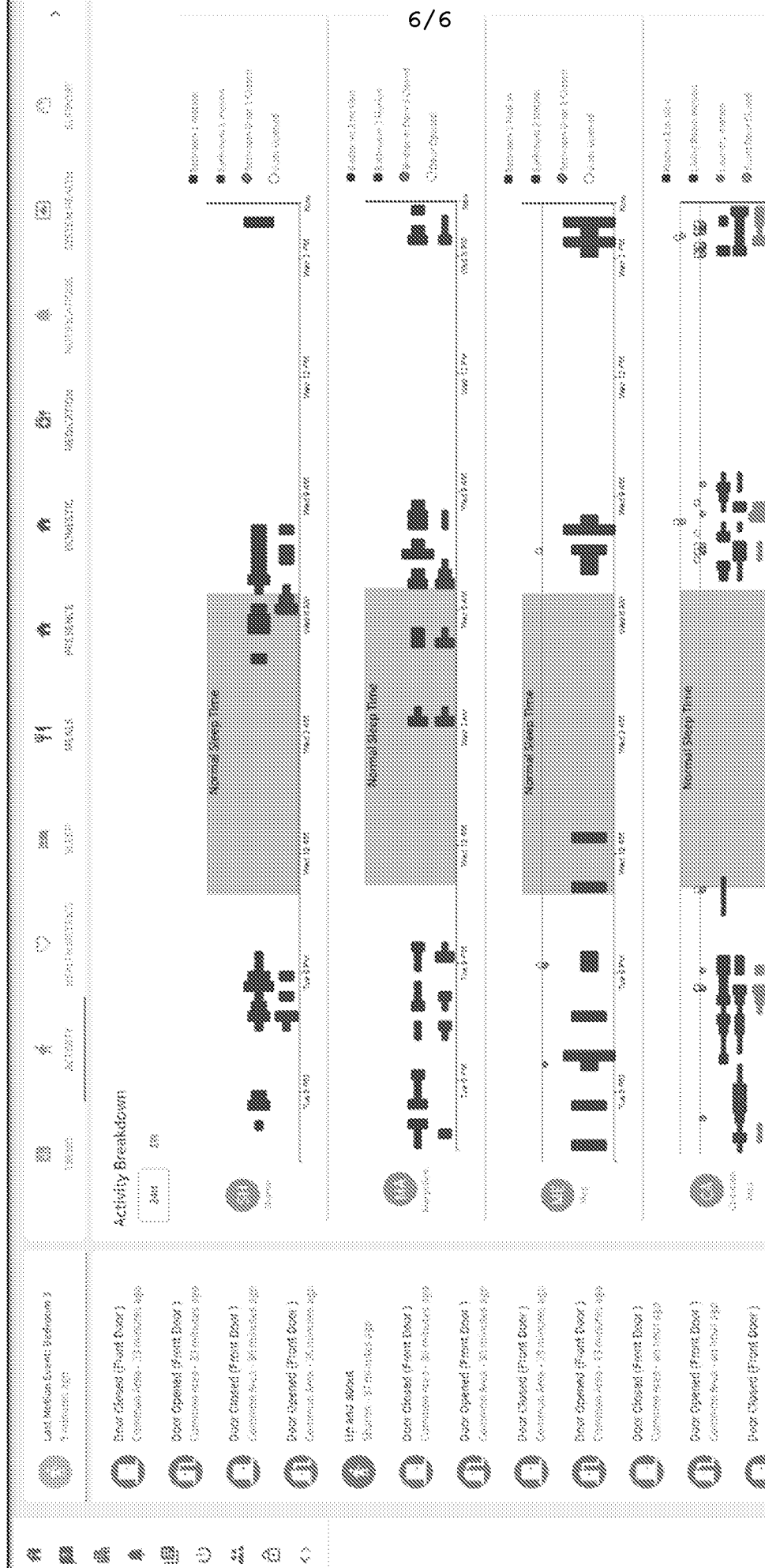


Figure 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2022/051433

A. CLASSIFICATION OF SUBJECT MATTER

G08B 1/08 (2006.01) G08B 21/02 (2006.01) G08B 21/04 (2006.01) G08B 23/00 (2006.01) G08B 25/00 (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)

Databases: DOCDB, DWPI, Google, Google Patents, Espacenet and PATENW
IPC/CPC: G08B21/04, G08B 25/01
Applicant: INTELICARE HOLDINGS
Keywords: motion, usage, pattern, behaviour, compare, alarm and similar terms.

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

* Special categories of cited documents:	
"A" 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
"D" document cited by the applicant in the international application	"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
"E" earlier application or patent but published on or after the international filing date	"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
"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)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
9 February 2023

Date of mailing of the international search report
09 February 2023

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INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/AU2022/051433
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/0360965 A1 (KONINKLIJKE PHILIPS N.V.) 15 December 2016 Abstract, figure 1A, 3, [0036], [0048]-[0049], [0063], [0067]-[0069], [0103]-[0108], [0161], [0133], [0155], [0278]	1-63
A	EP 1071055 A1 (MATSUSHITA ELECTRIC INDUSTRIAL CO. LTD) 24 January 2001 Whole document	1-63
A	US 2021/0063214 A1 (DAWNLIGHT TECHNOLOGIES INC.) 04 March 2021 Whole document	1-63

Form PCT/ISA/210 (fifth sheet) (July 2019)

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/AU2022/051433	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
US 2016/0360965 A1	15 December 2016	US 2016360965 A1	15 Dec 2016
		US 9901252 B2	27 Feb 2018
		US 2007085690 A1	19 Apr 2007
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US 2021186329 A1	24 Jun 2021		

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/AU2022/051433	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
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US 2021/0063214 A1	04 March 2021	US 2021063214 A1	04 Mar 2021
		WO 2021040888 A1	04 Mar 2021
End of Annex			

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.