Methods for Monitoring Body Position and for Affixing Objects to Garments

Title: METHODS FOR MONITORING BODY POSITION AND FOR AFFIXING OBJECTS TO GARMENTS

Abstract: Described herein are methods and apparatuses to mate an object with a cap through a fabric portion of the garment. The methods and apparatuses described herein may address the needs for a safe, secure, and detachable method and apparatus for affixing an object (such as an encased wireless sensor) to a garment worn by a subject.
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METHODS FOR MONITORING BODY POSITION AND FOR AFFIXING OBJECTS TO GARMENTS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority to U.S. patent application No. 14/565,169, filed on December 9, 2014 and titled "DETECTION OF CHANGES FROM A SEATED OR LYING BODY POSITION BY SENSING BODY ANGLE", and to U.S. patent application 14/702,398, filed on May 1, 2015, and titled "AFFIXATION OF OBJECTS TO GARMENTS." The entirety of each of these applications is herein incorporated by reference in its entirety.

INCORPORATION BY REFERENCE

[0002] All publications and patent applications mentioned in this specification are herein incorporated by reference in their entirety to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

FIELD

[0003] Methods and apparatuses for safely, securely, and detachably affixing an object (such as an encased wireless sensor device) to a garment. In particular, described herein are methods and apparatuses for securing a sensor to a garment of a subject and determining that the subject has gotten up from a bed or chair. These sensors may include body angle (body flexion angle) sensors.

BACKGROUND

[0004] There are an increasing number of people globally for whom transitions from a bed or chair subject them to a risk of accidental harm, and whose activity and location in an indoor environment, such as a house, a nursing care facility, or any building, needs to be closely monitored. For example, the elderly, those suffering from debilitating diseases, and those suffering from dementia (including Alzheimer's dementia) as well as other mental and medical conditions are at risk when transitioning from a sitting or lying position. For example, for the elderly and/or infirm, accidents and injuries may occur as a result of wandering out of a bed or chair. However, the need for constant vigilance may cause
significant stress to caregivers in home, hospitals and nursing facilities. It would be beneficial to provide methods and systems for detection and alerting of bed and/or chair leaving events, which could not only enhance the safety of subjects but also alleviate the stress of their caregivers. Further, it would also be beneficial to provide one or more methods and apparatuses for detecting and alerting caregivers of such transitions to prevent illness/accidents by remotely monitoring subject's routine activities without requiring the use of cameras due to privacy concerns.

Previous systems for monitoring subjects to prevent falls or wandering typically require more complex, and therefore expensive, methods to track subject movement. For example, Japanese Laid-Open Patent Application No. 2-280733 describes the use of load sensors installed on a subject's bed to detect his or her bed departure, and uses weight information to determine whether a user is still on the bed or has left the bed. Similarly, Japanese Patent No. 3093745, Japanese Patent No. 3322632, and U.S. Pat. No. 5,276,432 each describe the calculation of a subject's center of gravity from weight information of four points on a bed and use the center-of-gravity position information to monitor the movement of a user in bed. U.S. Pat. No. 6,239,706 disclosed describes an in-bed state determination based on measured load characteristics. These references, and similar techniques, all require specialized beds installed with load sensors (or retrofitted beds). The associated costs and cumbersome set-up prevent their wide applications in homes as well as in nursing facilities and hospitals.

As another solution, U.S. Pat. No. 8,736,439 uses a sensor sock to detect an individual leaving the bed by detecting a change in foot pressure. However, not all patients are comfortable wearing socks (especially when sleeping).

Alternatively, U.S. Pat. No. 6,307,481, U.S. Pat. No. 6,501,386, U.S. Pat. No. 6,661,347, U.S. Pat. No. 6,703,939, U.S. Pat. No. 6,864,796, U.S. Pat. No. 7,095,331, U.S. Pat. No. 7,145,461, and U.S. Pat. No. 7,479,890 describe systems to evaluate movement of a body relative to an environment by sensing dynamic and static accelerative phenomena, and determines whether the evaluated body movement is within an environmental tolerance. Unfortunately assumptions typically made by such systems about the patient's environment may not be accurate, or may lead to artifacts. In addition, such systems may be expensive and difficult to operate.

Finally, U.S. Pat. No. 8,814,811 describes a fall detection algorithm based on both the dynamic acceleration and static position signals and the high sampling rate required for acquiring the dynamic signal consumes energy.
Described herein are methods and apparatuses that may address the issues discussed above. For example, described herein are methods and apparatuses that may detect and notify caregivers that a patient being monitored (i.e., a subject) has changed body position in a manner that corresponds specifically with getting out of a bed or getting out of a chair. These apparatuses and methods are simple, relatively low-cost and easy to implement.

Methods that are based on measurement of body position and movement (including those described herein) may require a subject to wear a sensor device by affixing the device to the subject’s garment. Currently available means for doing this may include: (1) making the subject wear a chest belt or a watch embedded with the sensor; and (2) affixing sensor to a garment worn by the subject through a safety pin, Velcro, or a magnetic strip. These methods, however, do not work well for patients who suffer from Alzheimer’s, dementia, and other mental/memory conditions. These patients often refuse to wear any "foreign" objects such as a chest belt or a sensor wristband. Safety pins are not allowed for safety concerns. Affixation using interlocking Velcro is not secure enough as the patients can easily disengage the Velcro interlocking. US Pat. No. 5,369,899 discloses a method for affixing a magnetic nameplate by placing a magnetic strip behind the subject's garment, hence sandwiching the garment in between the strip and the nameplate. However, the user can easily take off the nameplate, causing concerns of a choking hazard, particularly for the subjects with memory impairments. Furthermore, magnets cause concerns of electromagnetic interference to pacemakers that have been implanted in some subjects.

Permanent affixation of a device to a garment is often not an option because of potential damage caused by laundry. A security tag is often affixed to merchandise garments using an elongated pin pieced through the garment and interlocked in a base plate, and a special tool is needed to disengage the interlocking mechanism when removing the tag. Recently, MonBaby (https://monbaby.com) has used a MonSnap method to affix a baby monitoring device to his/her clothes by snapping the device in a cap, thus sandwiching the garment in between. This method does not provide a secure affixation, because an adult can easily remove the device by popping the device out of the cap. Stretching the garment surrounding the device may also cause the device to pop out of the cap. In summary, there is a need for a method and apparatus for safely, securely, and detachably affixing an object to a garment, which only a skilled user can remove.
SUMMARY OF THE DISCLOSURE

[0011] Described herein are simple methods and a low-cost apparatuses to secure a device, such as a sensor, tracker, monitor or other device, to a subject's clothing in a lightweight and non-obtrusive manner, and particularly a reusable manner that does not damage the garment to which it is applied. For example, the methods and apparatuses described herein may be used to attach one or more sensors to the subject's clothing, e.g., to sense when a subject has gotten out of a bed or chair, and to remotely inform or alert caregivers. This may address the needs for not only detecting and alerting patients' wandering out of bed/chair, but also remotely monitoring a subject's routine life to detect illness and other unusual events. A subject, as used herein, may include a patient, or any other person in need of the monitoring described herein; subjects are not limited to hospital/medical patients, although the term "subject" and "patient" may be used interchangeably herein.

[0012] In general, a subject to be monitored may wear a small sensor, e.g., an angle-sensing unit, which can be directly affixed on the clothes, pajama, briefs, a belt or an accessory worn by the subject. The angle-sensing unit may preferably be tightly attached to the subject's body to accurately measure the subject's body angle. The unit may be oriented (e.g., so that an axis of the angle-sensing unit is generally oriented along the longitudinal axis of the subject) when placed on the subject. The unit generally includes an angle sensor that may measure an inclination angle (e.g. a static angle relative to gravity, for example), a microcontroller, a wireless transmitter, and a power supply. When the subject lies down on a bed or sits down on a chair, his or her initial body position may be set as a baseline. This may be done manually, e.g. by the monitoring caregiver, or automatically. When the subject changes his or her body angle by getting up, the sensor may detect a new body angle; if this new body angle exceeds the baseline angle by a predetermined amount (e.g., equivalent to greater than +/- 20°, 25°, 30°, 35°, 40°, 45°, 50°, 55°, 60°), the microcontroller may transmit a wireless signal, directly or through a server, to the caregiver's monitoring unit ("monitoring receiver"), which can be a smartphone, a smart watch, a tablet, a PC, a nurse station monitor, or a custom-made monitor. Various alerts can be issued on the monitor depending on whether the intended purpose is to detect wandering of a patient or an unusual event in daily routine life.

[0013] A plurality of the angle-sensing units can be monitored simultaneously by a single monitoring unit. Furthermore, the angle-sensing units and the monitoring unit can be further linked to a server through the Internet to form a service system.
These methods and systems for attaching a sensor to a subject's clothing may have numerous advantages over existing systems. For example, the body angle sensors described herein may detect a subject's getting up from the bed or the chair before his or her foot lands on the floor, which can prevent fall accidents. Further, by comparing the body angle (e.g., static body angle) with respect to its own baseline, the detection of the change in body becomes reliable.

In addition, the angle sensor may be positioned to measure gross body flexion angle only, and any rotations of the body in other directions will not affect the reliability of the detection.

Furthermore, to measure the static angle (rather than the dynamic acceleration), a low sampling rate (such as once every second) may be sufficient to sample the angle sensor, which may significantly save the power consumption, and reduce or eliminate the need for bulky batteries and may make the sensor circuit more wearable. Finally, the apparatuses described herein are easy to set up and operate, and may be produced and operated for very low cost.

Thus, described herein are methods of issuing an alert when a subject wearing an angle-sensing unit gets up from a bed or a chair. For example, such a method may comprise: setting, in a microcontroller connected to an angle sensor in the angle-sensing unit, a first value representing a first angle of the angle-sensing unit when the subject is sitting in a chair or reclined in a bed; sampling the angle sensor to determine a sampled value representing a sampled angle of the sensor; determining a difference between the sampled value and the first value to detect a change in the subject's body angle; and wirelessly transmitting an alert if the difference between the sampled value and the first value exceeds a threshold indicating that the subject has gotten up from the bed or out of the chair.

As mentioned, in general, setting the first value may comprise manually setting the first value once the subject reclines on a bed or sits in a chair. This may be performed by the caregiver, e.g., at the angle-sensing unit (by pressing a control, e.g., button, knob, dial, etc.) and/or at the monitoring station in communication with the sensor. Alternatively, the first value may be set automatically, shortly after being applied to the subject, by sampling the angle-sensing unit once it has been attached to the subject, assuming that the subject is in the initial position (e.g., recumbent on a bed, sitting in a chair, etc.).

The angle sensor of the angle-sensing unit may be sampled at any sampling rate, such as once every second (e.g. 1 Hz), or once every two seconds (0.5 Hz). The sample rate
may be modified or set by the caregiver. Sampling may comprise sampling the angle sensor at a preferred sampling rate to determine the sampled value.

[0020] In some variations the microcontroller compares the first (e.g., baseline) angle value to sensed angle values, or more accurately for both baseline and sensed angle values, values representing the angle of the angle-sensing unit and therefore body angle, in the angle-sensing unit; in some variations the angle-sensing unit transmits the sensed angle to a processor that is remote to the angle-sensing unit for performing the calculations.

[0021] In determining if an alert should be transmitted (or in some variations as mentioned above, simply raised) the apparatus may filter (e.g., average, limit, etc.) or select samples from the angle sensor that will be compared with the baseline value. In variations in which the angle sensor is detecting static angle of the angle-sensing unit (and therefore the subject's body) relative to gravity, for example, the value compared to the baseline (as well as the initial selection of the baseline) may be determined as a 'stable' or settled value, averaged (e.g., window averaged) or filtered to reduce other motion (and in particular other acceleration) artifacts. For example, either or both the steps of setting the first value and sampling the angle sensor may comprise measuring a static angle of the angle-sensing unit attached to the subject; in some variations the angle sensor comprises a single-axis accelerometer, or a 3-axis accelerometer.

[0022] In general, the methods described herein may include receiving the alert (e.g., at a monitoring unit) indicating that the subject wearing the angle-sensing unit has gotten up from a bed or out of a chair. Wirelessly transmitting an alert may include transmitting a signal to a monitoring receiver. The signal may be converted to one or more of: an audible sound, illuminating light, vibrating notification, or text message at the monitoring unit. Wirelessly transmitting an alert may include transmitting a wireless signal to a server through a monitoring unit or a gateway, wherein the server records the wireless signal into a database and provides data service to subscribing users.

[0023] Any of the methods described herein may also include attaching the angle-sensing unit to the subject, and/or instructing a caregiver to attach the angle-sensing unit to the subject. Attaching may be made in a specific manner, so that the angle-sensing unit (and in particular the angle sensor in the angle-sensing unit) is oriented relative to the subject's body. For example, it may be advantageous to attach the angle-sensing unit along the long axis of the subject's body (e.g., torso, neck, head, waist, thighs, etc.) with the angle-sensing unit configured so that an indicator (e.g., arrow, line, point, alphanumeric text, etc.) is oriented in the long axis, such as up towards the subject's head/crown or down toward their feet. In
general, it may be beneficial to orient the axis of the angle-sensing unit (and particularly the angle sensor) approximately along the long axis of the subject (e.g., within +/- 5°, 10°, 15°, 20°, etc.). Thus, any of the apparatuses described herein may include an indicator on the angle-sensing unit indicating the proper orientation of the angle-sensing unit relative to the subject's head, feet, etc. In some variations the system, such as the monitoring unit, may check with the caregiver to confirm that the angle-sensing unit is being worn by the subject with the angle-sensing unit oriented in the subject's long axis.

[0024] As mentioned, the angle-sensing unit may be worn directly on the subject's body (e.g., on their skin, adhesively attached, worn on a band or strap, etc., or it may be worn on (and/or integrated into) a garment worn by the subject, including (but not limited to) clothes, pajamas, hospital gown, briefs, a belt, or an accessory worn by the subject, or a medical device (e.g., catheter, tube, etc.). The angle-sensing unit may be worn tightly on the subject's body for accurate measurement of the subject's body angle.

[0025] Also described herein are methods of attaching to a garment one or more sensors, and/or monitoring a plurality of subjects each wearing an angle-sensing unit and issuing an alert when one of the plurality of subject gets up from a bed or a chair. For example, a method may include: setting, for each angle-sensing unit worn by one of the subjects in the plurality of subjects, a first value representing a first angle for the angle-sensing unit when the subject wearing the sensor is sitting in a chair or reclined in a bed; sampling, for each angle-sensing unit worn by one of the subjects in the plurality of subjects, an angle sensor of the angle-sensing unit to determine a sampled value representing a sampled angle of the sensor; determining, for each angle-sensing unit worn by one of the subjects in the plurality of subjects, a difference between the sampled value and the first value to detect a change in a body angle for the subject wearing each angle-sensing unit; and wirelessly transmitting, for each angle-sensing unit worn by one of the subjects in the plurality of subject's, an alert if the difference between the sampled value and the first value exceeds a threshold indicating that the subject has gotten up from the bed or out of the chair, wherein the alert comprises an identification number or name uniquely associated with the transmitting angle-sensing unit.

[0026] As described above, setting may comprise manually setting, for each angle-sensing unit worn by one of the subjects in the plurality of subjects, the first value once the subject reclines on a bed or sits in a chair. One or more alerts may be received (e.g., at a monitoring unit) indicating that one of the subjects has gotten up from a bed or out of a chair and identifying the angle-sensing unit transmitting the alert.
Thus, in any of the method and apparatuses described herein, an angle-sensing unit may include a unique (or may be caregiver-marked with a unique) identifier that corresponds to the subject wearing the angle-sensing unit. The unique identifier may be an alphanumeric, numeric, or the like, and may be transmitted with any of the transmissions (including but not limited to alerts) from the angle-sensing unit.

In some variations the monitoring unit may be configured to trigger an alert if the apparatus does not check in within a predetermined time period. For example, in some variations the system (e.g., the monitoring unit) may trigger an alert when periodic signals (including signals indicating that the body angle is not above the threshold indicating that the subject has gotten up) are not received as expected. For example, in some variations, the method may include generating an alert at a remote monitoring unit if a wireless transmission is not received for each angle-sensing unit worn by one of the subjects in the plurality of subject’s within a predetermined amount of time.

Also described herein are angle-sensing unit apparatus configured to determining when a subject wearing the apparatus gets up from a bed or a chair. For example, an angle-sensing unit apparatus may include: a wireless transmitter; an angle sensor configured to produce a signal corresponding to a static angle of the angle-sensing unit relative to a direction of gravity; a microcontroller connected to the wireless transmitter and to the angle sensor, the microcontroller configured to store a first value from the angle sensor representing a first angle of the angle-sensing unit when a subject wearing the angle-sensing unit is sitting in a chair or reclined in a bed, further wherein the microcontroller is configured to sample the angle sensor at a pre-determined sampling rate and determine a difference between the sampled values and the first value to detect a change in the subject’s body angle and to wirelessly transmitting an alert if the difference between the sampled values and the first value exceeds a threshold indicating that the subject has gotten up from the bed or out of the chair. As mentioned above, the angle sensor may be, e.g., a single-axis or a 3-axis accelerometer. Any of the apparatuses described herein may be configured (and may include any appropriate structure) to perform the functions described above. For example, any of the apparatuses described herein may be configured so that they include an orientation marking and/or structure indicating the alignment to be worn by the subject, and specifically, indicating that the device should be worn oriented in the subject’s long axis of the subject's body (e.g., pointing towards the head, etc.).
Also described herein are methods and apparatuses for safely, securely, and detachably affixing an object, such as a housing encasing the above angle sensing unit apparatus, to a garment.

In general, the disclosed method for affixing an object to a garment includes mating the object with a pairing cap through the fabric of the garment. The object may be shaped in a disc, whose side surface is configured with one or more spiral-shaped threads. The cap may be shaped in a ring, whose inner surface is configured with one or more spiral-shaped threads (which may also be referred to as tracks). By screwing the object into the cap through the fabric of the garment, the threads of the object are tightly fit inside the threads of the ring, providing a secured affixation of the object to the garment. The object may be removed from the garment by unscrewing the cap.

Another embodiment of the affixation method and apparatus incorporates an additional safety interlocking mechanism that requires an extra push of the cap in a certain direction before unscrewing to remove the object from the garment. Teeth are configured on the spiral-shaped threads, and tabs are configured on spiral-shaped threads. One of the teeth on each thread is interlocked with the tab on each thread (e.g., track) when the object and the cap are screwed together through the fabric, providing an extra layer of difficulty to remove the object from the garment. This extra safety is particularly desired when affixing a monitoring sensor device to a garment of a patient who suffers memory impairment.

Furthermore, the safety interlocking mechanism is equipped with an adjustment mechanism to accommodate garments with different thicknesses. This is accomplished by making the teeth on the spiral-shaped threads with an increasing thickness.

As mentioned, a garment includes, but is not limited to, clothes, pajamas, a hospital gown, briefs, a belt, a hat/cap, or a sock.

The object to be affixed to a subject's garment may be an encased sensor device. For example, described herein is a sensor apparatus configured to determining when a subject wearing the apparatus gets up from a bed or a chair. This apparatus may include (in addition to any of the features described herein): a housing enclosing a wireless sensor unit; the housing having a first engagement surface; an angle sensor within the housing configured to produce a signal corresponding to a body angle of the subject relative to a direction of gravity; a microcontroller connected to an RF transmitter and to the angle sensor, the microcontroller configured to detect a change in the subject's body angle and to wirelessly transmitting an alert if the subject gets up from the bed or out of the chair; and a cap
configured to mate with the first engagement surface of the housing through the fabric of a garment worn by the subject.

[0036] The housing (which may be referred to generically herein as an "object") may be disc-shaped with thickness and configured to fit into the cap, wherein the cap is annular.

Alternatively, the housing may be configured to enclose (though an intervening garment) the cap. In general, features on the cap (including the sensor/transmitter, controller, etc.) may be swapped between the object (housing) and the cap.

[0037] The engagement surface of the device housing may comprise one or a plurality of spiral-shaped threads. The cap may include one or a plurality of spiral-shaped threads (e.g., tracks) configured on its inner surface, into which the thread may fit when positioned with a fabric between the cap and the housing. Furthermore, tabs or teeth may be configured on the threads on housing and tabs may be adopted on the cap, so that the teeth and the tabs may be interlocked when the housing is screwed onto the cap through the fabric of the garment.

Furthermore, and teeth having different thicknesses may accommodate fabrics of different thicknesses.

[0038] Any of the methods described herein may also include instructing a user (such as a caregiver) to affix the object/housing to and remove it from the subject's garment. Affixation may be done in a manner such that the object/housing is securely screwed into the pairing cap with the garment sandwiched in between. Similarly, removal of the object from the garment may also be done in a manner such that the object is unscrewed from the paring cap. If the object is, for example, the encased body position sensing unit apparatus, an orientation will be marked on the surface of the case to ensure that a proper alignment of the sensor is maintained when affixing the device to the garment.

[0039] In some variations, the method includes removing the object (housing) from the garment by first releasing the safety interlocking mechanism before unscrewing the object from the paired cap.

[0040] The methods and apparatuses disclosed herein for affixation of an object to a garment offer many advantages over the existing methods and apparatuses. First, the screw/latching and the interlocking mechanisms make it difficult to remove the object from the garment, thus providing security of affixation and safety of the patients (to prevent choking accidents). Security and safety is highly needed when affixing wearable sensors/transceivers (such as the body angle monitoring unit mentioned above) to the garments of patients, particularly those suffer from memory impairment. Second, the
methods and apparatus do not involve any pins or magnets, and thus are safe to use on patients. Third, the object can be removed from the garment without requiring any tool.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0041] The novel features of the invention are set forth with particularity in the claims that follow. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings of which:

[0042] FIGS. 1 and 2 illustrate one example of a method and apparatus for detecting a subject's getting up from bed.

[0043] FIG. 3 is a schematic illustration of one embodiment of a sensor unit for detecting body angle, and therefore a change from sitting or lying positions. This sensor may include an angle sensor, a microcontroller, a wireless transmitter, and a power supply.

[0044] FIG. 4 is a schematic view showing a monitoring unit monitoring a plurality of sensor units.

[0045] FIG. 5 is a schematic view of a system for detecting body angle and notifying one or more caregivers that a subject (or subjects) has changed from sitting or lying positions. The system may include sensor units, a monitor, a gateway, and a server.

[0046] FIGS. 6 and 7 illustrate a method and apparatus for detecting a subject's getting up from a chair, as described herein.

[0047] FIGS. 8A and 8B illustrate one example of a sensor (e.g., shown in this example as a single-axis accelerometer) that may be used to detect a change in body angle as described herein.

[0048] FIG. 9 illustrates one example of the method and apparatus for affixing an object to a garment by screwing the object into a paired cap with the garment sandwiched in between.

[0049] FIG. 10 is a top view showing the object affixed to the garment.

[0050] FIG. 11 is a cross-sectional side view showing the object affixed to the garment.

[0051] FIG. 12 is a schematic view showing an example safety interlocking mechanism that further secures the affixation method.

[0052] FIG. 13 is a top view showing the object affixed to the garment with the safety interlocking mechanism.
FIG. 14 is a side view showing the object affixed to the garment with the safety interlocking mechanism.

FIG. 15 is a cross-sectional top view showing the object affixed to a thin garment with the safety interlocking mechanism.

FIG. 16 is a cross-sectional side view showing the object affixed to a thin garment with the safety interlocking mechanism.

FIG. 17 is a cross-sectional top view showing the object affixed to a thick garment with the safety interlocking mechanism.

FIG. 18 is a cross-sectional side view showing the object affixed to the thick garment with the safety interlocking mechanism.

FIG. 19 is a cross-sectional top view showing how to release the safety interlocking mechanism.

FIG. 20 is another example of a method and apparatus for affixing an object to a garment by screwing the object into a paired cap with the garment sandwiched in between.

FIG. 21A shows a front perspective view, FIG. 21B shows a back perspective view, FIGS. 21C and 21D show front and back views, respectively, FIG. 21E shows a side view, and FIG. 21F is a cross-sectional view through a midline of the apparatus.

FIGS. 22A and 22B show back and front perspective views, respectively, of cap portion.

FIGS. 23A-23C show back, front and side views, respectively, of the object having a housing that connects through a fabric to a cap such as the cap shown in FIGS. 22A-22B.

FIGS. 24A and 24B show the object housing of FIG. 23A-23C with a cover (shown in FIG. 24A removed, revealing the inner housing portion shown in FIG. 24B.

FIGS. 25A-25G illustrate one method of attaching the apparatuses described herein to a garment.

FIG. 26 illustrates components of an apparatus (e.g., system) for monitoring a person using an apparatus as described herein.

**DETAILED DESCRIPTION**

In general, described herein are methods and apparatuses for attaching one or more sensors to a subject's body. For example a sensor (e.g., devices such as angle-sensing
units and systems including one or more angle-sensing units and/or one or more monitoring units) can determine a change in gross body angle indicating that a subject wearing the device has gotten up and/or out of a bed, and in some variations a chair. Also described herein are apparatuses and methods for safely, securely, and detachably affixing objects (such as the angle-sensing units described herein) to clothing.

[0067] For example, FIG. 1, schematically illustrates operation of one variation of an angle-sensing unit. In FIG. 1, a subject 2 is shown lying down on a bed 3 wearing an angle-sensing unit 1 on his or her body. In general, the angle-sensing unit can be directly adhered to the subject's body, or affixed on the clothes, pajama, briefs, a belt or an accessory worn by the subject. The unit may be tightly attached to the subject's body to accurately measure the subject's body angle. The unit is oriented so that the initial body position 4 is detected (e.g., measured) by the sensor unit 1. This value may be set (e.g., automatically or manually by a caregiver) as the baseline body angle (e.g., a first angle of the angle-sensing unit). The angle-sensing unit may be oriented so when it is worn an axis of an angle sensor within the angle-sensing unit is approximately aligned with the long axis of the subject's body.

[0068] As shown in FIG. 2, when the subject 2 sits up, the body position and angle (as reflected by the angle of the angle-sensing unit) changed to a new position 5, and the body flexion angle 6 between the new position 5 and the baseline position 4 may be measured by the sensor 1. As will be described in greater detail below, an angle sensor within the angle-sensing unit may detect the static angle of the angle-sensing unit relative to gravity ("down") in the initial baseline position, and the angle-sensing unit may compare a value (e.g., a component of the acceleration due to gravity in a single axis, that may be approximately aligned with the subject's long axis) to the new value(s) sensed by the angle-sensing unit, as shown in FIG. 2. In this example, note that the angle-sensing unit does not need to calculate a complete angle, but may instead operate on the sensed values (current/voltage output by the accelerometer) representing these angles, and which may be converted to actual angle measurements. Thus, for example, the threshold values referred to herein may be in the same units as the sensed values for direct comparison (e.g., as acceleration values), but may correspond to threshold angles as recited herein.

[0069] In the example shown in FIGS. 1 and 2, when the measured angle 6 exceeds a predetermined threshold, the angle-sensing unit 1 may wirelessly sends a signal 7 to a monitoring unit 8, which can be a caregiver's unit. When the monitoring unit receives the signal 7, the monitoring unit 8 may generate an alert (e.g., an audible sound 9, and/or text alert, and/or vibration alert, and/or visual alert). The alert may also (or alternatively) include
a light illumination. The monitoring unit 8 can be a smartphone, a smart watch, a tablet, a PC, or a custom-made monitor. The wireless signal 7 can be transmitted through Bluetooth, Wi-Fi, ZigBee, Ant, or any wireless technologies.

FIG. 3 shows one example of a detailed schematic view of a preferred embodiment of an angle-sensing unit 1, comprising a power supply 10, the microcontroller 11, angle sensor 12, wireless transmitter 13, and a wireless antenna 14. The angle sensor 12 may generally measure the body angle 6, and the microcontroller 11 acquires the sensor data and compare the sensor data with the pre-determined body angle threshold (e.g., equivalent to greater than about +/- 20°, 25°, 30°, 35°, 40°, 45°, 50°, 55°, 60°). When the angle 6 exceeds the threshold, the microcontroller 11 may determine that the subject has gotten up from the bed, and subsequently commands the transmitter 13 to send a wireless signal 7 through antenna 14.

FIG. 4 is a schematic view of an embodiment of the sensor system, comprising a single monitoring unit 8 and a plurality of sensor units 1, each worn by a subject and uniquely identified by a number or name. This system allows one caregiver to monitor multiple subjects. When any of the sensor units sends a wireless signal to the monitoring unit, the monitor will issue an alert showing the specific identification number of the subject's name.

Sensor units 1 can be further linked to a server to form a service system that records and reports the subjects' history of data monitored by the sensor units 1. FIG. 5 is a schematic view of an embodiment of a service system comprising the angle-sensing unit(s) 1, a monitoring unit 8, a gateway unit 15, Internet 16, a server 17, an application 18, a database 19, and an additional monitoring unit 20. The angle-sensing unit(s) 1 may be connected to an internet 16 and further to the server 17 via the monitoring unit 8 or the gateway unit 15. Data from sensor unit 1 may be stored in the database 19. The application 18 associated with the database 19 may run on the server 17. The additional monitoring unit 20 allows additional users(s) to receive the alert 7 and subscribe to data service.

The benefit of having the gateway unit 15 such as that shown in FIG. 5 is that the monitoring unit 8 can be placed at a remote location beyond the wirelessly communicable range to the sensor unit 1, as long as the gateway is within the wirelessly communicable range to the sensor unit 1.

The methods and apparatuses described herein may also be used to detect when a subject rises out of a chair, as illustrated in FIGS. 6 and 7. In this example, the apparatus is shown detecting a subject getting up from a chair. In FIG. 6, the subject 2 wearing the angle-sensing unit is shown sitting on a chair 21, wearing the angle-sensing unit 1 on his or her
thigh. In general, the angle-sensing unit can be directly adhered to the subject's body, or affixed on the clothes, pajama, briefs, a belt or an accessory worn by the subject. The unit may preferably be tightly attached to the subject's body. The initial thigh position (angle) of measured by the sensor unit 1 may be set as the baseline thigh angle as discussed above. For example, this may be the angle or equivalent value relative to gravity ("down") using a single-axis or a 3-axis accelerometer. As the subject 2 gets up, the thigh position changes to a new position 5, having a new body angle. This change in body angle may be detected by the apparatus as the angle 6 between the new position 5 and the baseline position 4, e.g. as measured by the angle sensor of the angle-sensing unit 1. When this difference in the measured angle from the baseline 6 exceeds a pre-determined threshold (e.g., equivalent to greater than +/- 20°, 25°, 30°, 35°, 40°, 45°, 50°, 55°, 60°, or between any of these angles (e.g., between about 20° and 60°, etc.), the sensor unit 1 wirelessly sends a signal 7 to the monitoring unit 8, which can be a caregiver's unit. When it receives the signal 7, the monitoring unit 8 generates an alert, such as an audible sound 9 and/or a vibrating notification and/or a light illumination, etc. The monitoring unit 8 can be a smartphone, a smart watch, a tablet, a PC, or a custom-made monitor. The wireless signal 7 can be transmitted through Bluetooth, Wi-Fi, ZigBee, Ant, or any wireless technologies.

Although the example shown in FIGS. 6 and 7 include the sensor positioned on the subject's torso, and may detect, for example, the subject leaning forward when standing to get out of the chair; although a transient motion, if the sample rate for the sensor is sufficiently high (e.g., greater than a few times per second) the change in position, including the change in static angle, may be accurately sensed. However, in general, there may be preferred locations for placement of the angle-sensing units described herein, including on the subject's thigh, particularly for use in detecting standing from a sitting position, and on the subjects torso, neck or head, which may be particularly sensitive for detecting sitting up to get out of bed.

As mentioned above, in any of these variations, the angle-sensing unit includes an angle sensor. FIGS. 8A and 8B schematically illustrate a single-axis accelerometer that may be used as an angle sensor as described herein. Other angle sensors may be used (including multi-axis accelerometers including 3-axis accelerometers, gravity sensors, etc.). In reference to FIG. 8A and 8B, as an example, a single-axis accelerometer can be used to measure the static angle of the human body. When the accelerometer axis X is tilted with an angle \( \Theta \) with respect to the horizontal plane (e.g., perpendicular to the direction of gravity,
the accelerometer measures the vector component of the gravitational acceleration \( g \) projected to the X-axis, i.e.:

\[
A_x = g \times \sin(0)
\]

[0077]  

where \( A_x \) is the accelerometer\'s output acceleration. Therefore, the angle can be calculated as:

\[
\theta = \sin^{-1}(\frac{A_x}{g})
\]

[0079]  

In this example, the output value of the single-axis accelerometer may be particularly useful to approximate body angle, particularly when the x axis (which may be referred to as the axis of the angle sensor or the axis of the angle-sensing unit) is aligned with the long axis of the subject's body, generally extending from the top of the head to the feet. Further, it may be beneficial to measure only the static angle, separating out or ignoring the (rapidly-changing) dynamic forces on the sensor due to the movement (e.g., when sitting up). This may be achieved by filtering, averaging, and/or windowing the detected values. For example, rapid changes in the output of the angle sensor of the angle-sensing unit (e.g., the single-axis accelerometer) may be ignored in favor of static (steady-state) values, which may be persistent for two or more (e.g., 3, 4, 5, 6, 7, 8, etc.) sequential samples. The microcontroller may analyze the output of the angle sensor to make these determinations.

[0081]  

Also described herein are methods and associated apparatuses for safely, securely, and detachably affixing an object (such as an encased wearable sensor) to a garment. In addition, described herein are methods and apparatuses for simple and low-cost wireless geolocation of subjects with room-wise accuracy in an indoor environment.

[0082]  

For example, FIGS. 9 to 11 schematically illustrate the operation of one variation of an apparatus for affixing an object 101 to a garment 103 by screwing the object into a paired cap 102 with the garment 103 sandwiched between 101 and 102. In some versions, the object 101 is configured with a plurality of spiral-shaped threads 104, and the paired cap are fabricated with matching spiral-shaped threads 105. When the cap 101 is screwed into the cap 102 through the fabric 103, the threads 104 fit tightly inside the threads 105, thus providing secured affixation of the object to the fabric of the garment. Alternatively, the object 101 may be connected through the garment by a latching mechanism that is paired with the cap 102 on the opposite side of the garment. Although the threaded screw is one type of latching mechanism that may be used, an alternative latching mechanism may be, for example, one or more tabs that can be extended from either or both the object side to engage
a mating region on the cap side, and/or vice versa (e.g., tabs that extend from the cap side to engage a mating region on the object side. The tabs may be engaged through the fabric. For example, the tabs may be spring loaded and/or include a spring or other bias element to hold them in engagement. The tabs may be lockable in the engaged configuration (e.g., to prevent removal).

The affixation method may also require the user to affix the object to and later remove it from the garment. For example, affixation may be made in a manner such that the object is securely screwed into the pairing cap with the garment sandwiched in between. Similarly, removal of the object from the garment may also be made in a manner such that the object is unscrewed from the pairing cap.

In general, the object may be integrated with a sensor unit, or it may be a case holding the sensor unit for monitoring/tracking the subject's movements, location, etc. Other sensors may include sensors that monitor the wearer's vital signs, etc. As illustrated in FIG. 11, object 101 can be a case that houses a battery-powered wearable sensor unit, such as the body position sensing device as disclosed above. By securely affixing the sensor on the subject's garment with the initial sensor orientation properly maintained using a mark on its surface, the body position of the subject wearing the sensor can be accurately measured and monitored by the sensor.

The object may be integrated with an RF transceiver (a transmitter or receiver), or it may be a case holding the transceiver. As illustrated in FIG. 11, object 101 can also be a case that houses a battery-powered low-power transceiver circuit. Such a transceiver may be used for, but is not limited to, indoor geolocation of the subject who wears the transceiver.

FIGS. 12 to 14 schematically illustrate one version of a safety interlocking mechanism. A number of wedged teeth 108 are fabricated on each of the spiral-shaped threads on object 106, and a tab 110 is fabricated on each of the spiral-shaped threads on the inner surface of the cap 107. After screwing the object 106 into the cap 107 with the fabric sandwiched in between, one of the wedged teeth on each thread of the object is locked in with the tab on the matching threads of the cap. Therefore, the wedged interlocking mechanism provides an extra layer of security to the already secured affixation due to the use of the screw mechanism.

In some variations, the teeth interlocking the object with the cap may be 'dull', e.g., have rounded edges and/or smooth surfaces/edges, to prevent damaging the fabric interposed between the two. Rounded/dull edges may prevent snagging and/or puncturing the fabric.
The wedged interlocking mechanism may also be equipped with an adjustment mechanism to accommodate garments of different thicknesses. FIGS. 15 to 16 show cross-sectional top views of the middle of the object 106 and the cap 107. In this example, the teeth engaging an interlock (e.g., 110) in the threaded region have different thicknesses (or gradually decrease in the gap between the teeth in the counterclockwise direction), allowing for different thicknesses of fabrics there between. For example, the fabric 103 in FIG. 15 is thicker than the fabric 111 in FIG. 16. Therefore, the interlocking 110 takes place in different teeth - the tooth with a larger gap for the thicker fabric (FIG. 15) and the tooth with a smaller gap for the thinner fabric (FIG. 16). With the gradually decreasing gap between the wedge teeth 108 in the counterclockwise direction, this affixation method can accommodate a variety of the garment thicknesses. For example, a thicker fabric is locked at the first pair of wedges that has a larger gap, while a thin fabric is locked at the last pair of wedges, which has a smaller gap.

As shown in FIG. 17 (thick fabric) and FIG. 18 (thin fabric), the difference in the garment thickness results in the difference in the vertical gap between the object 106 and the cap 107; the thick garment causes a larger vertical gap. However, the difference in fabric thickness does not affect the gap in the radial direction, as illustrated in FIG. 15 and FIG. 16.

When removing the object from the garment, the cap may be first squeezed in a certain location to disengage the wedged interlocking mechanism before unscrewing the object from the cap. FIG. 19 illustrates the unlocking process by exerting a pair of pushing force 112 on the cap 107 with the hands of the user to deform the cap and release the wedged interlocking mechanism, before unscrewing the object 106 and cap 107 off the garment 103.

The methods and apparatuses disclosed herein for affixation of an object to a garment offer many advantages over the existing methods and apparatuses. First, the screw/latching and the interlocking mechanisms make it difficult to remove the object from the garment, thus providing security of affixation and safety of the patients (to prevent choking accidents). Security and safety is highly needed when affixing wearable sensors/transceivers (such as the body angle monitoring unit mentioned above) to the garments of patients, particularly those suffer from memory impairment. Second, the methods and apparatus do not involve any pins or magnets, and thus are safe to use on patients. Third, the object can be removed from the garment without requiring any tool.

This attachment mechanism for mating an object (including encased sensor/transceiver device) onto a garment can have a variety of manifestations.
As described above, in general, the garment attachment apparatuses described herein for attaching to a subject’s garment may include two parts, and object and a cap. The object may be equivalently referred to as an object housing, a sensor housing, a sensor object housing, or an inner member. Any of these object housings may include an internal cavity and a cover that is sealed or removable. In general a sensor and/or control circuitry coupled to the sensor may be housed within the housing. The housing may be sealed to prevent tampering. The housing may be sealed to prevent the incursion of water or other contaminants (e.g., urine, etc.). A button or other control may be included on the housing (e.g., on an outer or outward-facing surface, configured to be worn away from the patient's skin when attached to a garment). The button may allow activation (e.g., by pushing) of a control within the housing. The button may also be sealed (e.g., may include a sealing ring or membrane) preventing fluid from entering. The button may be biased, e.g., by a spring other biasing member, so that it may be pushed to overcome the bias, then return to the original (un-pushed) position after release.

The cap may also be referred to as a ring, annular member, annular ring, annular cap, or the like. Any of the caps described herein may include a central opening into which the object housing may fit, and may also include one or more lateral openings on a distal-facing and/or side-facing wall, or extending over a lip or edge from the distal-facing to side-facing wall. These lateral openings may allow the fabric to extend through the opening slightly, allowing it to secure more tightly between the cap and object, as is shown in FIGS. 14 (144) and FIGS. 21A-22B.

Any of the garment attachment apparatuses described herein may also include a stop on the cap and/or object housing to prevent over-tightening of the garment attachment apparatus to the garment. For example in FIGS. 9 and 11, the cap 102 may include a stop (which may also be referred to as a stopper) at one end of the threads to prevent over-tightening. In any of these variations the object may include a stop to prevent over-tightening. For example, the object may include a shoulder, lip or rim the limits how deeply into the cap the object may be screwed.

FIG. 20 illustrates another variation of a garment attachment apparatus that includes a cap configured as a ring 505 and an object housing 511. The apparatus shown in FIG. 20 is configured to safely, securely, and detachably affix to a portion of a garment and includes an object housing 502 and a cap (ring 505), which are shown positioned on either side of a fabric 506. The object housing 511 has a cylindrical body 501 that includes one or more spiral-shaped threads 503 on a lateral side surface 514 of the body. The object housing
also may include an endcap 502 perpendicular to the later side surface, the endcap forming a lip (which may also be referred to as a shoulder region) extending laterally to or beyond the one or more spiral-shaped threads; in FIG. 20, it extends slightly beyond the lateral edge of the threads. The endcap may equivalently be referred to as a head, or the head of the object (object housing 511).

[0097] The cap is configured a ring 505 that is threaded 504 on the inner surface with threads that mate with the complimentary threads on the outer surface of the object housing, as previously discussed. In this example, the cap and the object mate together similar to a bolt and nut, where the object corresponds to the bolt and the nut corresponds to the cap. As in any of these variations, the object (object housing 511) may enclose one or more sensor and/or circuitry for controlling and transmitting signals from the sensor(s), including, but not limited to, a body angle flexion sensor as discussed above.

[0098] FIGS. 21A-21F illustrate another variation of a garment attachment apparatus 600. This example is similar to the variation shown in FIGS. 9-11, discussed above. In this example the apparatus includes an object (object housing 601) and a cap 605. FIGS. 21A and 21B show top and bottom perspective views, respectively, of the garment attachment apparatus in which the top is screwed onto the bottom; for clarity, the garment to which the garment attachment apparatus is attached is not shown.

[0099] In this example, one side (e.g., the outward-facing or front side) of the object includes a button 609 that can be used to mechanically transmit a control input to a device (e.g., controller) inside of the object housing. The object (object housing 601) may also include a gripping surface 606 that can be used to aid in attaching or releasing the object housing from the cap. For example, in FIG. 21B, the object housing is a slot that may be used (e.g., with a coin, flathead screwdriver, etc.) to aid in screwing/unscrewing the object from the cap.

[0100] FIGS. 21C and 21D show front and back views, respectively of the same apparatus shown in FIGS. 21A-21B. As mentioned above, the cap 605 in any of these examples may include one or more openings 615. These openings 615 may extend through the lateral and/or forward facing sides of the cap. The openings may allow the garment material to extend slightly (e.g., bulge) through, preventing wrinkles, and allowing a tighter attachment. FIG. 21E shows a side view, also showing these openings 615 through the cap.

[0101] In general, any of the objects (object housings) described herein may house a cavity for holding one or more sensors and/or control circuitry. FIG. 21F shows a sectional
view through the apparatus of FIGS. 21A-21E, showing the inner chamber 622 of the object 601.

[0102] FIGS. 22A and 22B show the cap of the apparatus shown in FIGS. 21A-21E isolated from the rest of the apparatus, in back and front perspective views, respectively.

FIGS. 23A, 23B and 23C show back perspective, front perspective and side views, respectively, of the object housing shown in FIGS. 21A-21E. FIGS 24A and 24B show the object housing opened by removing a top cover 704 (FIG. 24A) from the object housing to reveal the inside of the object housing in FIGS. 24B. This housing may enclose a sensor and control circuitry (not shown) as discussed above, and may receive input through the button 709 as discussed above. Structures held within the housing may be secured within the housing in a fixed position. The housing may also include a seal or gasket 711; alternatively or additionally this internal member may secure any sensors and/or control circuitry within the housing.

[0103] FIGS. 25A-25G illustrate one method of attaching an apparatus as described herein to a garment. Any of the steps of this exemplary method may be incorporated partially or entirely within any other method for attaching the apparatuses described herein to a garment. In FIG. 25A, the object housing 801 is shown lying on a garment 803 with a front side facing outward. In this example the front side may include markings and/or controls (e.g., buttons). The garment may be arranged so that the front side is facing a direction away from the wearer's body when the garment is worn. Thus, in this first step the sensor may be placed on one side of a fabric portion of the garment (e.g., the outer side). The sensor may then be wrapped with the fabric portion of the garment, as shown in FIG. 25B and 25C. This may include forming a pouch 806 of material with the object housing held within the pouch 806. The tail portion of the pouch 807 (the bunched up portion of the garment behind the object housing) may be held by a user's hand, as shown in FIG. 25, and used to secure the object housing without touching it, with the fabric so that the cap 809 may be screwed on, as shown in FIGS. 25D-25E. The cap is applied over the fabric pouch holding the object housing. While holding the fabric (with the object inside) tight, the cap may be screwed 811 to the object through the fabric forming the pouch, as shown in FIG. 25F. Once tightened on, the apparatus 800 is secured to the garment, as shown in FIG. 256.

[0104] Any of the systems described herein may be secured to a subject's clothing and used, by housing a sensor such as a body flexion angle sensor. The sensor may communicate with a handheld and/or wearable computing device of a caregiver, such as a smartphone, via a direct wireless connection (e.g., Bluetooth, Wi-Fi, etc.) between the devices, or through an
internet connection (e.g., via a gateway 900, as shown in FIG. 5 and FIG. 26). Thus, any of
the apparatuses described herein may be used to monitor a subject wearing the apparatus
from any room in a structure (home, hospital, etc.) and are typically easy to secure by the user
(caregiver) and difficult to remove by the patient. Multiple patients may be monitored using
a single mobile device, since each apparatus may include a unique identifier that may be
transmitted with the sensor output.

[0105] When a feature or element is herein referred to as being "on" another feature or
element, it can be directly on the other feature or element or intervening features and/or
elements may also be present. In contrast, when a feature or element is referred to as being
"directly on" another feature or element, there are no intervening features or elements
present. It will also be understood that, when a feature or element is referred to as being
"connected", "attached" or "coupled" to another feature or element, it can be directly
connected, attached or coupled to the other feature or element or intervening features or
elements may be present. In contrast, when a feature or element is referred to as being
"directly connected", "directly attached" or "directly coupled" to another feature or element,
there are no intervening features or elements present. Although described or shown with
respect to one embodiment, the features and elements so described or shown can apply to
other embodiments. It will also be appreciated by those of skill in the art that references to a
structure or feature that is disposed "adjacent" another feature may have portions that overlap
or underlie the adjacent feature.

[0106] Terminology used herein is for the purpose of describing particular embodiments
only and is not intended to be limiting of the invention. For example, as used herein, the
singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the
context clearly indicates otherwise. It will be further understood that the terms "comprises"
and/or "comprising," when used in this specification, specify the presence of stated features,
steps, operations, elements, and/or components, but do not preclude the presence or addition
of one or more other features, steps, operations, elements, components, and/or groups thereof.
As used herein, the term "and/or" includes any and all combinations of one or more of the
associated listed items and may be abbreviated as "/".

[0107] Spatially relative terms, such as "under", "below", "lower", "over", "upper" and
the like, may be used herein for ease of description to describe one element or feature's
relationship to another element(s) or feature(s) as illustrated in the figures. It will be
understood that the spatially relative terms are intended to encompass different orientations of
the device in use or operation in addition to the orientation depicted in the figures. For
example, if a device in the figures is inverted, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. Thus, the exemplary term "under" can encompass both an orientation of over and under. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly. Similarly, the terms "upwardly", "downwardly", "vertical", "horizontal" and the like are used herein for the purpose of explanation only unless specifically indicated otherwise.

Although the terms "first" and "second" may be used herein to describe various features/elements (including steps), these features/elements should not be limited by these terms, unless the context indicates otherwise. These terms may be used to distinguish one feature/element from another feature/element. Thus, a first feature/element discussed below could be termed a second feature/element, and similarly, a second feature/element discussed below could be termed a first feature/element without departing from the teachings of the present invention.

As used herein in the specification and claims, including as used in the examples and unless otherwise expressly specified, all numbers may be read as if prefaced by the word "about" or "approximately," even if the term does not expressly appear. The phrase "about" or "approximately" may be used when describing magnitude and/or position to indicate that the value and/or position described is within a reasonable expected range of values and/or positions. For example, a numeric value may have a value that is +/- 0.1% of the stated value (or range of values), +/- 1% of the stated value (or range of values), +/- 2% of the stated value (or range of values), +/- 5% of the stated value (or range of values), +/- 10% of the stated value (or range of values), etc. Any numerical range recited herein is intended to include all sub-ranges subsumed therein.

Although various illustrative embodiments are described above, any of a number of changes may be made to various embodiments without departing from the scope of the invention as described by the claims. For example, the order in which various described method steps are performed may often be changed in alternative embodiments, and in other alternative embodiments one or more method steps may be skipped altogether. Optional features of various device and system embodiments may be included in some embodiments and not in others. Therefore, the foregoing description is provided primarily for exemplary purposes and should not be interpreted to limit the scope of the invention as it is set forth in the claims.
The examples and illustrations included herein show, by way of illustration and not of limitation, specific embodiments in which the subject matter may be practiced. As mentioned, other embodiments may be utilized and derived therefrom, such that structural and logical substitutions and changes may be made without departing from the scope of this disclosure. Such embodiments of the inventive subject matter may be referred to herein individually or collectively by the term "invention" merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept, if more than one is, in fact, disclosed. Thus, although specific embodiments have been illustrated and described herein, any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.
CLAIMS

What is claimed is:

1. A method of safely, securely, and detachably affixing an object onto a portion of a garment, wherein the object is configured to mate with a cap through a fabric region of the garment, the method comprising:
   - placing the fabric region between the object and the cap; and
   - mating the object and the cap together with the fabric region there between.

2. The method of claim 1, further comprising wrapping the fabric region over the object.

3. The method of claim 2, wherein mating comprises holding the fabric tightly with the object secured inside the fabric while screwing the cap onto the object with the fabric region there between.

4. The method of claim 1, wherein the object is shaped in a disc with one or more spiral-shaped threads configured on its side surface, and the cap is shaped in a ring with one or more spiral-shaped threads configured on its inner surface, so that the one or more spiral-shaped threads of the object and the one or more spiral-shaped threads of the cap are engaged when screwing the object into the cap through the fabric.

5. The method of claim 4, further comprising an interlocking region with teeth configured on the threads of the object and tabs configured on the threads of the cap, wherein the teeth are interlocked with the tabs when the object and the cap are screwed together through the fabric.

6. The method of claim 5, wherein the teeth are arranged with a decreasing gap between adjacent teeth so that different thicknesses of fabric may be held between the object and the cap.

7. The method of claim 1, further comprising removing the object from the garment by disengaging the object from the cap.

8. The method of claim 4, further comprising removing the object from the garment by unscrewing the object from the cap.
9. The method of claim 5, further comprising removing the object from the garment by squeezing the cap to release the interlocking teeth and tabs and then unscrewing the object from the cap.

10. An apparatus configured to safely, securely, and detachably affix an object to a portion of a garment, the apparatus comprising:
   - an object shaped in a disc having a thickness, comprising one or a plurality of spiral-shaped threads on a side surface, and
   - an annular cap comprising one or a plurality of spiral-shaped threads on an inner surface configured to mate with the spiral-shaped threads of the object/housing through a fabric of the garment.

11. The apparatus of claim 10, further comprising an interlocking region with teeth on the spiral-shaped threads of the object/housing and tabs on the cap, configured so that the teeth interlock with the tabs when the object and the cap are screwed together through the fabric of the garment.

12. The apparatus of claim 11, wherein the teeth are arranged around the spiral-shaped thread with a decreasing gap between the teeth so that different thicknesses of fabric may be held between the object/housing and the cap.

13. A method of safely, securely, and detachably affixing a device, such as a sensor device or a transceiver device, onto a portion of a garment worn by a subject, wherein the device is enclosed in a housing configured to mate with a cap through a fabric region of the garment, the method comprising:
   - placing the fabric region between the housing and the cap; and
   - mating the housing and the cap together with the fabric therethrough.

14. The method of claim 13, wherein the device is enclosed in a disc-like housing with spiral-shaped threads configured on the side surface, and the cap is shaped in a ring with spiral-shaped threads configured on the inner surface, so that the threads of the housing and the threads of the cap are engaged when screwing the housing into the cap through the fabric.

15. The method of claim 15, further comprising an interlocking region with taps or teeth configured on the threads of the housing and tabs configured on the cap, so
that the teeth are interlocked with the tabs when the housing and the cap are
screwed together through the fabric.

16. The method of claim 15, wherein the teeth are arranged with a decreasing gap
between adjacent teeth so that different thicknesses of fabric may be held between
the housing and the cap.

17. The method of claim 13, further comprising removing the device from the
garment by disengaging the housing from the cap.

18. The method of claim 15, further comprising removing the device from the
garment by unscrewing the housing from the cap.

19. The method of claim 16, further comprising removing the device from the
garment by squeezing the cap to release the interlocking teeth and tabs and then
unscrewing the housing from the cap.

20. The method of claim 13, wherein the device within the housing is a sensor unit
configured to produce a signal corresponding to a static flexion angle of the body
of the subject wearing the device, and a microcontroller inside the sensor unit
configured to detect a change in the subject's body angle and to wirelessly
transmit an alert or generate an alert on the device, when the subject gets up from
the bed or out of the chair resulting in an increase in his or her body flexion angle.

21. A method of safely, securely, and detachably affixing a body flexion angle sensor
coupled to an object onto a portion of a garment, wherein the object is configured
to mate with a cap through a fabric region of the garment, the method comprising:

placing the fabric region between the object and the cap; and

mating the object and the cap together with the fabric region there between

wherein the body flexion angle sensor includes a microcontroller and is
configured to produce a signal corresponding to a flexion angle of a body
of a subject wearing the garment and to communicate the signal to the
microcontroller to detect a change in the subject's body flexion angle, and
to generate, transmit or generate and transmit an alert when the change in
the subject's body flexion angle exceeds a threshold indicating that the
subject has gotten up form a bed or out of a chair.
22. The method of claim 21, wherein the object is shaped in a disc with one or a plurality of spiral-shaped threads configured on its side surface, and the cap is shaped in a ring with one or a plurality of spiral-shaped threads configured on its inner surface, so that the threads of the object and the threads of the cap are engaged when screwing the object into the cap through the fabric.

23. The method of claim 22, further comprising an interlocking region with teeth configured on the threads of the object and tabs configured on the cap, wherein the teeth are interlocked with the tabs when the object and the cap are screwed together through the fabric.

24. The method of claim 23, wherein the teeth are arranged with a decreasing gap between adjacent teeth so that different thicknesses of fabric may be held between the object and the cap.

25. The method of claim 24, further comprising removing the object from the garment by disengaging the object from the cap.

26. The method of claim 22, further comprising removing the object from the garment by unscrewing the object from the cap.

27. The method of claim 24, further comprising removing the object from the garment by squeezing the cap to release the interlocking teeth and tabs and then unscrewing the object from the cap.

28. An apparatus configured to safely, securely, and detachably affix a body flexion angle sensor coupled to an object to a portion of a garment, the apparatus comprising:

- an object shaped in a disc having a thickness, comprising one or a plurality of spiral-shaped threads on a side surface,
- an annular cap comprising one or a plurality of spiral-shaped threads on an inner surface configured to mate with the spiral-shaped threads of the object through a fabric of the garment, and
- a body flexion angle sensor including a microcontroller, wherein the body flexion angle sensor is configured to produce a signal corresponding to a flexion angle of a body of a subject wearing the garment and to
communicate the signal to the microcontroller to detect a change in the subject's body flexion angle, and to generate, transmit or generate and transmit an alert when the change in the subject's body flexion angle exceeds a threshold indicating that the subject has gotten up from a bed or out of a chair.

29. The apparatus of claim 28, further comprising an interlocking region with teeth on the spiral-shaped threads of the object-and tabs on the cap, configured so that the teeth interlock with the tabs when the object and the cap are screwed together through the fabric of the garment.

30. The apparatus of claim 29, wherein the teeth are arranged with a decreasing gap between the teeth so that different thicknesses of fabric may be held between the object and the cap.

31. A method of safely, securely, and detachably affixing a body flexion angle sensor onto a portion of a garment worn by a subject, wherein the body flexion angle sensor is enclosed in a housing configured to mate with a cap through a fabric region of the garment, the method comprising:
   placing the fabric region between the housing and the cap; and
   mating the housing and the cap together with the fabric therethrough, wherein the body flexion angle sensor includes a microcontroller and is configured to produce a signal corresponding to a static flexion angle of a body of a subject wearing the garment and to communicate the signal to the microcontroller to detect a change in the subject's body flexion angle, and to generate, transmit or generate and transmit an alert when the change in the subject's body flexion angle exceeds a threshold indicating that the subject has gotten up from a bed or out of a chair.

32. The method of claim 31, wherein the device is enclosed in a disc-like housing with one or a plurality of spiral-shaped threads configured on the side surface, and the cap is shaped in a ring with one or a plurality of spiral-shaped threads configured on the inner surface, so that the one or a plurality of threads of the housing and the one or a plurality of threads of the cap are engaged when screwing the housing into the cap through the fabric.
33. The method of claim 32, further comprising an interlocking region with teeth configured on the threads of the housing and tabs configured on the cap, so that the teeth are interlocked with the tabs when the housing and the cap are screwed together through the fabric of the garment.

34. The method of claim 33, wherein the teeth are arranged with a decreasing gap between adjacent teeth so that different thicknesses of fabric may be held between the housing and the cap.

35. The method of claim 31, further comprising removing the device from the garment by disengaging the housing from the cap.

36. The method of claim 32, further comprising removing the device from the garment by unscrewing the housing from the cap.

37. The method of claim 33, further comprising removing the device from the garment by squeezing the cap to release the interlocking teeth and tabs and then unscrewing the housing from the cap.

38. An apparatus configured to safely, securely, and detachably affix a sensor to a portion of a garment, the apparatus comprising:

   an object housing having a cylindrical body that includes one or more spiral-shaped threads on a lateral side surface and an endcap perpendicular to the lateral side surface, the endcap forming a shoulder extending laterally to or beyond the one or more spiral-shaped threads; and

   an annular ring comprising one or more spiral-shaped threads on an inner surface that are configured to mate with the spiral-shaped threads of the object housing through a fabric of the garment.

39. The apparatus of claim 38, further comprising a sensor within the object housing, the sensor comprising a body flexion angle sensor including a microcontroller, wherein the body flexion angle sensor is configured to produce a signal when an angle between the subject's torso and one or more of the subject's extremities changes above a threshold, indicating that the subject has gotten up from a bed or out of a chair.
40. The apparatus of claim 38, further comprising a button on the object housing.

41. A method of issuing an alert when a subject wearing an angle-sensing unit gets up from a bed or a chair, the method comprising:
   - setting, in a microcontroller connected to an angle sensor in the angle-sensing unit, a first value representing a first angle of the angle-sensing unit when the subject is sitting in a chair or reclined in a bed;
   - sampling the angle sensor to determine a sampled value representing a sampled angle of the sensor;
   - wirelessly transmitting an alert if the sampled value is changed from the first value indicating that the subject has gotten up from the bed or out of the chair; and
   - receiving the alert at a monitoring unit.

42. The method of claim 41, wherein setting the first value comprises manually setting the first value once the subject reclines on a bed or sits in a chair.

43. The method of claim 41, further comprising receiving the alert indicating that the subject has gotten up from a bed or out of a chair.

44. The method of claim 41, further wherein receiving the alert at the monitoring unit comprises receiving the alert in the monitoring unit and the monitoring unit comprises: a smartphone, a smart watch, a tablet, a PC, or a dedicated monitor.

45. The method of claim 41, wherein setting the first value comprises measuring a static angle of the angle-sensing unit attached to the subject, wherein the angle sensor comprises an accelerometer.

46. The method of claim 41, further comprising attaching the angle-sensing unit to the subject.

47. The method of claim 41, wherein sampling the angle sensor to determine a sampled value comprises averaging a plurality of samples to determine the sampled value.
48. The method of claim 41, wherein setting the first value comprises setting the first value once the subject is wearing the angle-sensing unit on the subject's waist, chest, or thigh.

49. The method of claim 41, wherein setting the first value comprises setting the first value once the subject is wearing the angle-sensing unit affixed to clothes, pajamas, briefs, a belt, or an accessory worn by the subject.

50. The method of claim 41, wherein wirelessly transmitting an alert comprises transmitting a signal to a monitoring unit, further wherein the signal is converted to one or more of an audible sound, illuminating light, vibrating notification, or text message at the monitoring unit.

51. The method of claim 41, wherein wirelessly transmitting an alert comprises transmitting a wireless signal to a server through a monitoring unit or a gateway, wherein the server records the wireless signal into a database and provides data service to subscribing users.

52. The method of claim 41, further comprising generating an alert at a remote monitoring unit if a wireless transmission is not received from the angle-sensing unit within a predetermined amount of time.

53. A method of monitoring a plurality of subjects each wearing an angle-sensing unit and issuing an alert when one of the plurality of subject gets up from a bed or a chair, the method comprising:

   setting, for each angle-sensing unit worn by one of the subjects in the plurality of subjects, a first value representing a first angle for the angle-sensing unit when the subject wearing the sensor is sitting in a chair or reclined in a bed;

   sampling, for each angle-sensing unit worn by one of the subjects in the plurality of subjects, an angle sensor of the angle-sensing unit to determine a sampled value representing a sampled angle of the sensor;

   determining, for each angle-sensing unit worn by one of the subjects in the plurality of subjects, a difference between the sampled value and the first value to detect a change in a body angle for the subject wearing each angle-sensing unit;
wirelessly transmitting, for each angle-sensing unit worn by one of the subjects in the plurality of subject’s, an alert if the difference between the sampled value and the first value exceeds a threshold indicating that the subject has gotten up from the bed or out of the chair, wherein the alert comprises an identification number or name uniquely associated with the transmitting angle-sensing unit; and receiving one or more alerts at a monitoring unit indicating that one of the subjects has gotten up from a bed or out of a chair and identifying the angle-sensing unit transmitting the alert.

54. The method of claim 53, wherein setting comprises manually setting, for each angle-sensing unit worn by one of the subjects in the plurality of subjects, the first value once the subject reclines on a bed or sits in a chair.

55. The method of claim 53, wherein receiving one or more alerts at the monitoring unit comprises receiving one or more alerts at the monitoring unit and the monitoring unit comprises: a smartphone, a smart watch, a tablet, a PC, a nurse station monitor, or a dedicated monitor.

56. The method of claim 53, wherein setting comprises, for each angle-sensing unit worn by one of the subjects in the plurality of subjects, measuring a static angle of the angle-sensing unit attached to the subject, wherein the angle sensor comprising an accelerometer

57. The method of claim 53, wherein wirelessly transmitting comprises transmitting a wireless signal to a server through a monitoring unit or a gateway, wherein the server records the wireless signal into a database and provides data service to subscribing users.

58. The method of claim 53, further comprising generating an alert at a remote monitoring unit if a wireless transmission is not received for each angle-sensing unit worn by one of the subjects in the plurality of subject’s within a predetermined amount of time.

59. An angle-sensing unit apparatus configured to determining when a subject wearing the apparatus gets up from a bed or a chair, the apparatus comprising:
a wireless transmitter;
angle sensor configured to produce a signal corresponding to a static angle of
the angle-sensing unit relative to a direction of gravity;
a microcontroller connected to the wireless transmitter and to the angle sensor,
the microcontroller configured to store a first value from the angle sensor
representing a first angle of the angle-sensing unit when a subject wearing
the angle-sensing unit is sitting in a chair or reclined in a bed;
further wherein the microcontroller is configured to sample the angle sensor
and determine a difference between the sampled values and the first value
to detect a change in the subject's body angle and to wirelessly
transmitting an alert if the difference between the sampled values and the
first value exceeds a threshold indicating that the subject has gotten up
from the bed or out of the chair.

60. The apparatus of claim 59, wherein the angle sensor comprises an accelerometer.
A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. A44B99/00 (2010.01) i, A61B5/107 (2006.01)i, A61B5/11 (2006.01)i, G08B21/02 (2006.01) i

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)

Int.Cl. A44B99/00, A44B1/06, A44B1/18, A44B1/30-1/32, A41D1/00, A41D27/08, F16B39/30, A61B5/107, A61B5/11, G08B21/02

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

Published examined utility model applications of Japan 1990-1996
Published unexamined utility model applications of Japan 1971-2016
Registered utility model specifications of Japan 1996-2016
Published registered utility model applications of Japan 1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>X</td>
<td>JP 2005-95228 A (MORITO CO., LTD.) 2005.04.14, paragraphs [0012]-[0014], figures 1-6 (Family: none)</td>
<td>1-2,7</td>
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<tr>
<td>X</td>
<td>JP 11-177662 A (NEC MOBILE COMMUNICATIONS, LTD.) 1999.07.02, paragraphs [0008]-[0010], figures 1-3 (Family: none)</td>
<td>1-2,7, 13, 17</td>
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<td>X</td>
<td>US 2075722 A (ILLSCHE, Arthur) 1937.03.30, page 2, left-hand column, lines 26-43, page 2, right-hand column, lines 5-22, 49-56, figures 1-3</td>
<td>1-4, 7-8, 10, 13-14, 17-18, 38</td>
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<td>(Family: none)</td>
<td>5-6, 9, 11-12, 15-16, 19-37, 39-40</td>
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☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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

Date of the actual completion of the international search

23.03.2016

Date of mailing of the international search report

05.04.2016

Name and mailing address of the ISA/JP

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Authorized officer

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<th>Relevant to claim No.</th>
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<td>Y</td>
<td>WO 2014/029594 A2 (OBRIST CLOSURES SWITZERLAND GMBH) 2014.02.27, page 8, line 14 to page 10, line 5, figures 1-9 &amp; EP 2888489 A2</td>
<td>5-6, 9, 11-12, 15-16, 19, 23-25, 27, 29-30, 33-34, 37</td>
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<td>Y</td>
<td>JP 2003-61935 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 2003.03.04, paragraphs [0033], [0060] - [0068], figures 1, 8-10 (Family: none)</td>
<td>20-37, 39-40</td>
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<tr>
<td>Y</td>
<td>JP 4-12733 A (NEC SAN-EI INSTRUMENTS LTD.) 1992.01.17, page 4, upper left column, line 14 to upper right column, line 10, figure 3 (Family: none)</td>
<td>39</td>
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</table>
INTERNATIONAL SEARCH REPORT

Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☑ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2. ☑ Claims Nos.:
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☑ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

This Authority considers that the application does not meet the requirements of unity of invention and that there are 2 inventions covered by the claims indicated as follows:

D1: JP 2005-95228 A (MORITO CO., LTD.)
   2005.04.14, paragraphs [0012]-[0014], figures 1-6 (Family: none)

D2: JP 11-177662 A (NEC MOBILE COMMUNICATIONS, LTD.)
   1999.07.02, paragraphs [0008]-[0010], figures 1-3 (Family: none)

[Continued on an extra sheet]

1. ☑ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☑ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☑ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☑ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-40

Remark on Protest

☑ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☒ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.
(Invention 1) Claims 1-40

D1 discloses "A method of safely, securely, and detachably affixing an object (2) onto a portion of a garment (N), wherein the object (2) is configured to mate with a cap (3) through a fabric region of the garment (N), the method comprising: placing the fabric region between the object (2) and the cap (3); and mating the object (2) and cap (3) together with the fabric region there between, and further comprising wrapping the fabric region over the object (2)" (see paragraphs [0012]-[0014], figures 1-6).

D2 also discloses "A method of safely, securely, and detachably affixing an object (1) onto a portion of a garment (6), wherein the object (1) is configured to mate with a cap (2) through a fabric region of the garment (6), the method comprising: placing the fabric region between the object (1) and the cap (2); and mating the object (1) and cap (2) together with the fabric region there between, and further comprising wrapping the fabric region over the object (1)" (see paragraphs [0008]-[0010], figures 1-3).

Therefore, claims 1-2 lack novelty over D1 or D2 and include no special technical features.

However, claim 3, which is a dependent claim of claim 1, includes "wherein mating comprises holding the fabric tightly with the object secured inside the fabric while screwing the cap onto the object with the fabric region there between" as a special technical feature, and claims 4-6, 8-12, 14-16, 18-19, 22-30, 32-34, 36-40 also include the corresponding technical feature.

Therefore, claims 1-6, 8-12, 14-16, 18-19, 22-30, 32-34, 36-40 are grouped into Invention 1.

Further, claims 7, 13, 17, 20-21, 31, 35 are dependent claims of claim 1 and have an inventive link to claim 1, thus those claims are grouped into Invention 1.

(Invention 2) Claims 41-60

Claims 41-60 and claim 3 in Invention 1 involve neither the same nor the corresponding special technical features.

Further, claims 41-60 are not dependent claims of claim 1. Those claims are neither substantially identical, nor similarly closely related, with any claim grouped into Invention 1.

Therefore, claims 41-60 cannot be grouped into Invention 1.

Then, claims 41-52 include "A method of issuing an alert when a subject wearing an angle-sensing unit gets up from a bed or a chair, the method comprising: setting, a first value representing a first angle of the angle-sensing unit when the subject is sitting in a chair or reclined in a bed; sampling the angle sensor to determine a sampled value representing a sampled angle of the sensor; wirelessly transmitting an alert if the sampled value is changed from the first value indicating that subject has gotten up from the bed or out of the chair; and receiving the alert at a monitoring unit" as a common technical feature, and claims 53-60 also include the corresponding technical feature.

Therefore, claims 41-60 are grouped into Invention 2.

[End]