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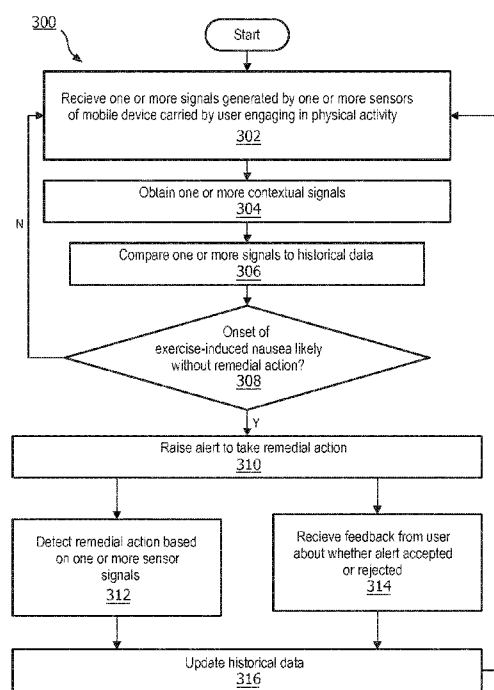


FIG. 3

(57) Abstract: In various embodiments, one or more sensors of one or more mobile computing devices (100) carried by a user (118) engaging in a physical activity may generate one or more signals indicative of one or more health parameters of the user. In some embodiments, the one or more signals may be compared (306) with historical data associated with engagement by one or more users in one or more physical activities. In some embodiments, a determination may be made (308) based on the comparing that the user likely will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions. In response, an alert may be raised (310) to be provided to the user to take one or more remedial actions. In some embodiments, the historical data may be updated (316) based on a user reaction to the alert.

EXERCISE-INDUCED NAUSEA WARNING SYSTEMS AND METHODS

Technical Field

[0001] Various embodiments described herein are directed generally to health care. More particularly, but not exclusively, various methods and apparatus disclosed herein relate to warning systems and methods for exercise-induced nausea.

Background

[0002] Exercise-induced nausea is a feeling of sickness that may occur during or after strenuous exercise. It may include a variety of symptoms, such as cold sweats, excessive salivation, headache, dizziness, flushed skin, loss of appetite, retching/gagging, vomiting, muscle tremors, diarrhea, frequent swallowing, licking lips, etc. Exercise-induced nausea may be caused by a variety of factors, such as dehydration, over-hydration (hyponatremia), and/or over exertion. In some cases, blood flow taken away from the stomach can cause nausea. As populations adopt so-called “high performance living” lifestyles in response to recent trends in obesity due to sedentary lifestyles, exercise-induced nausea has become more common.

Summary

[0003] The present disclosure is directed to warning systems and methods for exercise-induced nausea. In various embodiments, one or more mobile computing devices carried or worn by a user, such as a smart watch, an activity tracker, a mobile phone, etc., may include one or more sensors to detect various physical and other attributes of a user while the user exercises or otherwise engages in strenuous physical activity that could potentially lead to exercise-induced nausea. Data indicative of the signals from the one or more sensors may be compared to historical data associated with, for instance, past instances of exercise-induced nausea experienced by the user or by a population of users. Based on the comparison, a determination may be made, e.g., at the mobile device, that the user is likely to experience exercise-induced nausea unless the user somehow changes her behavior, e.g., by taking a remedial action such as resting, slowing down, etc. The user may be notified of the determination so that the user can take appropriate responsive action (or ignore the notification).

[0004] Generally, in one aspect, a computer-implemented method may include: receiving, by one or more processors, one or more signals generated by one or more sensors of one or more mobile

computing devices carried by a user engaging in a physical activity, wherein the one or more signals are indicative of one or more health parameters of the user; comparing, by the one or more processors, the one or more signals with historical data associated with engagement by one or more users in one or more physical activities; determining, by the one or more processors based on the comparing, that the user likely will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions; and raising, by the one or more processors, an alert to be provided to the user to take one or more remedial actions in response to the determining. In various embodiments, the one or more sensors may include an accelerometer, a heart rate monitor, a position coordinate sensor, and/or a sweat sensor.

[0005] In various embodiments, the comparing may include providing, as inputs to a machine learning model, data indicative of the one or more signals from the one or more sensors. In various versions, the determining may be based on a classification provided by the machine learning model. In various embodiments, the determining may include: calculating, based on the comparing, a likelihood that the user will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions; and determining that the likelihood satisfies a predetermined threshold.

[0006] In various embodiments, the historical data may include personal historical data associated with prior performance of the physical activity by the user. In various embodiments, the historical data may include aggregate historical data associated with prior performance of the physical activity by a plurality of users. In various embodiments, the historical data may include personal historical data associated with prior performance by the user of another physical activity different than the physical activity. In various embodiments, the historical data may include aggregate historical data associated with prior performance by a plurality of users of one or more other physical activities different than the physical activity.

[0007] In various embodiments, the method may include: receiving, by the one or more processors, feedback from the user, the feedback indicative of whether the user accepted or rejected the alert; and updating, by the one or more processors, the historical data based on the feedback and the one or more signals. In various embodiments, the method may include: detecting, by the one or more processors based on one or more subsequent signals from the one or more sensors, that the user took remedial action; and updating, by the one or more processors, the historical data based on the detecting.

[0008] In various embodiments, the method may include: receiving, by the one or more processors, unsolicited input from the user, the unsolicited input indicative of exercise nausea the user is experiencing or expects to experience; in response to the unsolicited input, obtaining, by the one or more processors, from the one or more sensors, one or more additional signals indicative of one or more health parameters of the user; and updating, by the one or more processors, the historical data based on the unsolicited input and the one or more additional signals.

[0009] Other embodiments may include a non-transitory computer readable storage medium storing instructions executable by a processor to perform a method such as one or more of the methods described above. Yet another implementation may include a system such as a wearable computing device that includes memory and one or more processors operable to execute instructions, stored in the memory, to implement a method such as one or more of the methods described above.

[0010] In another aspect, a wearable computing device may include: one or more sensors configured to measure one or more health parameters of a user wearing the wearable computing device; one or more input components; and logic operably coupled with the one or more sensors and the one or more input components. The logic may be configured to: receive, via the one or more input components, unsolicited input from the user while the user engages in a physical activity, the unsolicited input indicative of exercise nausea the user is experiencing or expects to experience; in response to the unsolicited input, obtain one or more signals generated by the one or more sensors, wherein the one or more signals are indicative of the one or more health parameters of the user when the user provided the unsolicited input; and update historical data associated with engagement by one or more users in one or more physical activities based on the unsolicited input and the one or more signals generated by the one or more sensors.

[0011] It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent) are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein. It should also be appreciated that terminology explicitly employed herein that also may appear in any disclosure incorporated by reference should be accorded a meaning most consistent with the particular concepts disclosed herein.

Brief Description of the Drawings

[0012] In the drawings, like reference characters generally refer to the same parts throughout the different views. Also, the drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating various principles of the embodiments described herein.

[0013] Fig. 1 schematically illustrates components of a mobile device configured with selected aspects of the present disclosure, in accordance with various embodiments.

[0014] Fig. 2 depicts the Keller index of Nausea.

[0015] Fig. 3 depicts an example method of detecting the onset of exercise-induced nausea and providing a warning thereof, in accordance with various embodiments.

[0016] Fig 4 depicts an example computer system architecture.

Detailed Description

[0017] Exercise-induced nausea is a feeling of sickness that may occur during or after strenuous exercise. It may include a variety of symptoms, such as cold sweats, excessive salivation, headache, dizziness, flushed skin, loss of appetite, retching/gagging, vomiting, muscle tremors, diarrhea, frequent swallowing, licking lips, etc. Exercise-induced nausea may be caused by a variety of factors, such as dehydration, over-hydration, and/or over exertion. As populations become more active, exercise-induced nausea has become more common. Accordingly, Applicants have recognized and appreciated that it would be beneficial to proactively warn users when they are likely to experience exercise-induced nausea should they not alter their immediate behavior. In view of the foregoing, various embodiments and implementations of the present disclosure are directed to determining, based on a variety of signals, that a user is likely to experience exercise-induced nausea if he or she does not change her immediate behavior, and providing the user with a warning.

[0018] Referring to Fig. 1, a mobile device 100 configured with selected aspects of the present disclosure is shown in the form of a smart watch. However, this is not meant to be limiting. Mobile device 100 may come in other form factors, such as a smart phone, an activity tracker meant to be carried in a pocket to secured to the skin, a smart hat or headband, smart glasses, smart apparel (e.g., clothing with sewn-in circuitry that performs selected aspects of the present disclosure), and so forth. Mobile device 100 may include a variety of standard computing components, such as logic

102, memory 104, one or more input components 106, one or more output components 108, one or more communications modules 110_{1-M}, a power supply (not depicted), and so forth. In various embodiments, one or more of these components may be operably coupled via one or more buses 112. Only selected buses 112 are labeled in Fig. 1 for the sakes of clarity and brevity.

[0019] Logic 102 may come in various forms. In some embodiments, logic 102 may take the form of one or more processors, and memory 104 may store instructions that may be executed by the one or more processors to perform various techniques described herein. In some embodiments, logic 102 may take the form of an application-specific integrated circuit (“ASIC”) or a field-programmable gate array (“FPGA”). Memory 104 may come in various forms as well, including but not limited to volatile memory such as high-speed random access memory or non-volatile memory such as magnetic disk storage devices, optical storage devices, and flash memory.

[0020] One or more input components 106 may take various forms to receive input using a variety of modalities. In some embodiments, mobile device 100 may include a touch screen display that can receive input. Additionally or alternatively, mobile device 100 may include various “soft” keys, buttons, knobs, and so forth. In some embodiments, one or more sensors 114 (which will be described in more detail below) may additionally or alternatively be used as input components 106. For example, an accelerometer may be used to detect a gesture made by a user while holding mobile device 100. Input components 106 may also include a microphone to receive voice input, a camera to receive visual input, and so forth. One or more output components 108 may take various forms as well. These may include one or more speakers, displays (e.g., touch screen or otherwise), haptic feedback devices (e.g., to provide vibration), and so forth.

[0021] Communications modules 110_{1-M} may be standalone devices or components of devices that facilitate communication, e.g., sending and receiving of commands, triggers, notifications, prompts, acknowledgments, information, messages, forms, and various types of data such as video, text, and audio between, for example, mobile device 100 and one or more other computing devices 116₁₋₃ operated or otherwise associated with a user 118 over one or more networks 111. In accordance with various embodiments, communications modules 110_{1-M} may include any transmitter or receiver used for Wi-Fi, Bluetooth, infrared, NFC, radio frequency, cellular communication, visible light communication, Li-Fi, WiMAX, ZigBee, fiber optic and other forms of wireless communication devices. Alternatively, the communications modules 110_{1-M} may be physical channels such as USB cables, Ethernet cables, or other wired forms of communication. One or

more networks 111 may include one or more wireless or wired personal area networks (“PANs”), local area networks (“LANs”), and/or wide area networks (“WANs”) such as the Internet. In some embodiments, mobile device 100 may have two or more different types of communications modules, such as one for cellular communication, and another for Bluetooth, and perhaps even another for Wi-Fi.

[0022] Mobile device 100 may include various types of sensors 114. Each sensor may be configured to sense, detect, and/or measure some physical characteristic of the user 118 and/or of a context of the user (e.g., the user’s location). Each sensor 114 may then provide, e.g., to logic 102, a signal indicative of the sensed/detected/measured physical characteristic. Sensors 114 may include but are not limited to accelerometers, thermometers, pedometers, position coordinate sensors (e.g., GPS), sweat sensors, barometers, barometric altimeters, heart rate monitors, cameras (e.g., to detect pulse and/or respiratory rate), microphones, and so forth.

[0023] In order to determine when user 118 is likely going to experience exercise-induced nausea without a change in behavior, various historical data pertaining to physical activities engaged in by user 118 personally and/or users in general may be tracked. Such historical data may be stored in various locations. For example, at least some historical data may be stored in an index 120 contained in memory 104 of mobile device 100. Index 120 may include, for instance, historical data pertaining to user 118 and/or a population of users of which user 118 is a member, such as friends on a social network, contacts, fellow gym members, teammates, co-workers, and so forth. Historical data may be stored elsewhere as well, such as in a historical data index 122 maintained on one or more computing systems (e.g., a server farm) located remotely from mobile device 100 and/or other computing devices 116.

[0024] In some embodiments, historical data personal to user 118 may begin as a baseline established by user 118 in various ways. In some embodiments, prior to user 118 engaging in physical activity while wearing/carrying mobile device 100, user 118 may provide mobile device 100 with some sort of empirically and/or user-defined maximum exertion threshold. Additionally or alternatively, user 118 may calibrate mobile device 100 by exercising. For example, when the user begins to feel exercise-induced nausea set in while exercising, user 118 may, with or without solicitation of input from mobile device 100, operate one or more input components 106 of mobile device 100 to indicate that user 118 is beginning to experience and/or is experiencing exercised-induced nausea. Or, one or more objective symptoms of exercise-induced nausea (e.g., as set forth

in the Keller Index) may be detected from user 118 by one or more sensors 114. Either way, mobile device 100 may poll the various sensors 114 and/or other “contextual” data points (e.g., time of day, user’s age, user’s sleep diary, etc.) to generate a “snapshot” of a state of user 118 that may be used as an exercise-induced nausea baseline moving forward. In some embodiments, the user may be provided an opportunity to accept or reject the baseline snapshot. For example, a user may swipe away a baseline notification to reject it. If the user accepts the baseline notification (or in some cases takes no responsive action), then the snapshot may be established as baseline historical data for the user.

[0025] After baseline historical data is established, mobile device 100 may in the future, alone or in combination with other components depicted in Fig. 1, use the baseline and any subsequently-added historical data to detect and warn user 118 when user 118 likely will experience exercise-induced nausea if user 118 does not alter his or her behavior. For example, in some embodiments, logic 102 of mobile device 100, or logic of other computing devices such as 116₁₋₃, may receive one or more signals generated by one or more sensors 114 while user 118 engages in a physical activity. The one or more signals may be indicative of one or more health parameters of the user, including but not limited to heart rate, respiratory rate, steps taken, location (including change in location), one or more sweat characteristics, temperature, or any other physical characteristic of user 118 and/or of a context of user 118 that can be detected by sensors 114_{1-N}.

[0026] These received sensor signals, alone or in combination with other “contextual” data points (e.g., age, weight, other demographics of user 118, workout time, calendar, social network status, etc.) may be compared with historical data pertaining to user 118 personally (e.g., the baseline described above plus any subsequently collected data) and/or to a plurality of users generally. The historical data may be further associated with the same activity that user 118 is engaging in (e.g., running, walking, dancing, playing sports, etc.), and/or with activities that are deemed to be similarly strenuous as the activity that user 118 is engaging in. In some embodiments, the comparison may involve providing, as inputs to a trained machine learning model (trained, for example, based on the historical data), data indicative of the one or more signals from the one or more sensors 114.

[0027] Based on the comparison, it may be determined that user 118 likely will experience exercise-induced nausea if user 118 continues engaging in the physical activity without taking one or more remedial actions. For example, a snapshot of all the sensor readings may be packed into a feature vector instance that is then classified by a machine learning model as suggestive of imminent

exercise-induced nausea. Various machine learning classification models may be employed, including but not limited to linear/logistic regression models, neural network models, *etc.* Various learning algorithms for training such models may be used such as, for example, batch or stochastic gradient descent or application of the normal equations..

[0028] Or, in some embodiments, a likelihood that the user will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions may be calculated, e.g., by logic 102, and then a determination may be made that the likelihood satisfies a predetermined threshold. However the determination is made, an alert may be raised in response, e.g., by mobile device 100 using output components 108 and/or by one or more other computing devices 116, that user 118 should take one or more remedial actions to avoid the onset of exercise-induced nausea. In response to the alert, the user may take various remedial actions, such as slowing down, stopping, etc.

[0029] The system may continue to “learn” about the proclivity of user 118 to experience exercise-induced nausea by continuing to update the historical data based on user response to alerts. In various embodiments, the historical data may be updated in response to various events. For example, in some embodiments, when user 118 takes remedial action in response to alert, that may be detected (e.g., an accelerometer may detect that the user slowed down or stopped) by one or more sensors 114 of mobile device 100. The fact that user 118 took such remedial action may be used in conjunction with the sensor measurements that triggered the alert as, for instance, a positive training example provided to a machine learning model. The positive training example may indicate that a classification by the machine learning model that the user was imminently going to experience exercise-induced nausea was likely accurate. Similarly, if user 118 takes no remedial action in response to an alert, that may be used as a negative training example. In some embodiments, after the user ignores the alert (e.g., by failing to take any remedial action), the device may continue to monitor the user for signs of nausea and, if they continue to increase, label the example as a positive training example (because, even though the user ignored the alert, they went on to experience nausea increase). Additionally or alternatively, user 118 may respond to an alert by taking some action using mobile device 100 (or another computing device 116) to explicitly accept or reject the alert, such as swiping away a notification. Such a response by user 118 may be used in conjunction with the sensor measurements that triggered the alert as an additional positive or negative training example.

[0030] In addition to learning about the user's proclivity to experience exercise-induced nausea, these techniques may also facilitate evolution of the user's historical data over time to track the user's physical fitness. As user 118 exercises regularly and becomes more fit, one or more thresholds associated with imminent exercise-induced nausea may be raised. Likewise, as user 118 neglects exercise, the same or similar thresholds may be lowered. And of course the user may manually adjust thresholds as the user sees fit, e.g., to account for circumstances that may not be easily detectable by sensors 114.

[0031] While in the example in Fig. 1 described above, much of the decision making occurs on mobile device 100, this is not meant to be limiting. In various embodiments, selected aspects of the present disclosure may be distributed across multiple computing devices, such as across mobile device 100 and one or more other computing devices 116. In some embodiments, mobile device 100 may take the form of a sports watch, with at least one sensor 114 coming in the form of a heart rate meter. Other components depicted as being integral to mobile device 100 may be integral to such a sports watch, and/or may be distributed elsewhere (e.g., on other computing devices 116).

[0032] Fig. 2 depicts the Keller Index of Nausea. This index includes various subjective symptoms and changes in behavior that may commonly be observed among many individuals who are experiencing exercise-induced nausea. One or more of these symptoms and/or changes in behavior may serve as an indicator that may be used to calculate in an objective manner whether a particular individual is experiencing or will likely soon experience exercise-induced nausea. Some of these symptoms may be measureable or detectable using various sensors 114 of mobile device 100. For example, several of "Alterations in affect and behaviors," such as the individual putting her hand over her mouth or stomach, may be detected by an accelerometer contained in a smart watch worn around a user's wrist. One or more of the "Distress" symptoms, such as nausea facial expression, could be detected by facial recognition processes using image data captured by a camera. Other types of sensors could be employed to capture one or more of the "Physiological Alterations." For example, image data captured by a camera, or a signal from a heart monitor, may be used to detect a respiratory rate. Audio data from a microphone (e.g., on a wrist-worn device or disposed in the ear of the patient, for example, as part of a headphone) may be used to detect the sounds of vomiting, retching, gagging, or swallowing. Cold sweat may be detected by various moisture, sweat, and/or temperature sensors. Cold skin may be detected, for instance, using a

digital temperature sensor (*e.g.*, disposed in a wrist-worn device or otherwise in contact with the user). In some embodiments, movements associated with physiological alterations such as vomiting or retching may be detected by comparing a signal from an accelerometer to movement profiles known to be associated with vomiting or retching or generally with nausea (*e.g.* holding a hand over the mouth or stomach). In some embodiments, a separate model may be trained to recognize these gestures from accelerometer, positional, and other available sensor data and/or to recognize which such gestures correspond to nausea for that particular user. Thus, another trained model may be used to extract features from available sensor data that will be used in conjunction with the nausea prediction model (*e.g.*, for construction of the training set and for application of the model to a feature vector).

[0033] Other sensors may be deployed elsewhere on the user's body to detect other symptoms of exercise-induced nausea. In some embodiments these sensors may communicate with a mobile device 100 over one or more personal area networks (*e.g.*, Bluetooth). For example, one or more sensors may be deployed on or inside of a user's mouth to detect excessive salivation, frequent swallowing, tongue movements, and so forth. Such sensors could include, for example, microphones, cameras, moisture sensors, etc. In some embodiments, such a sensor may be included on a mouth guard worn, for instance, by athletes playing sports.

[0034] Referring back to Fig. 1, alerts raised by mobile device 100 (*e.g.*, through output component(s) 108) may convey various types of information. In various embodiments, the alert may prompt user 118 to take one or more remedial actions, such as "slow down," "take x minute break," "stretch," "stop immediately," and so forth. In some embodiments, the suggested remedial actions may be to eat food and/or rehydrate. In some embodiments, user 118 may be prompted to hydrate and/or eat food well ahead of imminent exercise-induced nausea. For example, logic 102 may determine that user 118 previously experienced exercise-induced nausea while engaging in a particular physical activity on an empty stomach (which may have been determined, for instance, from manual input from user 118 or from an electronic food log maintained by user 118). When user 118 begins performing the same exercise, an alert may be raised suggesting that the user eat something first to prevent the previously-experienced exercise-induced nausea.

[0035] Referring to Fig. 3, an example method 300 for predicting and warning a user of imminent exercise-induced nausea is provided. While the operations of method 300 are depicted in

a particular order, this is not meant to be limiting. Various operations may be reordered, added, and/or omitted.

[0036] At block 302, one or more sensor signals may be received, e.g., by logic 102, from one or more sensors (e.g., 114) of a mobile device (e.g., 100) carried or worn by a user (e.g., 118) engaging in a physical activity such as running, walking, swimming, playing a sport, lifting weights, etc. These sensor signals may be indicative of a variety of physical characteristics of the user that are described above. At block 304, one or more contextual signals may be obtained, e.g., by logic 102, from a variety of sources. As used herein, “contextual signals” may refer to data points associated with a user that are not physically sensed by a sensor, but instead are obtained from one or more information sources associated with a user. For example, a user’s calendar or social network status update could reveal that the user is scheduled to go (or is) running. Or a user’s GPS sensor may detect that the user is located at the gym, perhaps even on a particular exercise machine. Or, a pregnancy-tracking application on the user’s phone may reveal that the user is pregnant (such a fact may increase the likelihood of exercise-induced nausea).

[0037] At block 306, the one or more sensor and/or contextual signals may be compared to historical data. As noted above, historical data may include subjective data that is personal to the user (e.g., baseline data and subsequently learned data) as well as objective data that is observed across a plurality of users. In some embodiments, objective historical data associated with users sharing one or more attributes with a user-of-interest may be considered. For example, if the user is a thirty-two year old woman, then objective historical data associated with women in their thirties may be used. And as noted above, sensor/contextual signals may be compared to historical data in various ways. In some embodiments, each sensor/contextual signal may provide one or more data points to be used as part of an input vector for a trained machine learning model.

[0038] At block 308, based on the comparison at block 306, a determination may be made whether the user is likely going to experience exercise-induced nausea if the user fails to change his or her behavior. If the answer is no, then method 300 may return to block 302. However, if the answer at block 308 is yes, then method may proceed to block 310.

[0039] At block 310, one or more alerts may be raised, e.g., by mobile device 100 and/or other computing devices, such as 116. For example, a user’s smart watch or a smart phone strapped to the user’s arm may vibrate to catch the user’s attention. When the user looks at a display of the watch or phone in response to the vibration, a prompt may be rendered suggesting that the user take

remedial action to avoid exercise-induced nausea. Additionally or alternatively, the user's watch or phone may beep at the user to catch her attention, and may visually or audibly notify the user that exercise-induced nausea is imminent without some change in behavior.

[0040] At noted above, a user's proclivity for exercise-induced nausea may be learned over time and/or updated to reflect changes in the user's physical fitness. This is demonstrated by blocks 312 and 314, of which neither, one, or both may be performed. These blocks are associated with determining whether the determination made at block 308 to raise the alert at block 310 was proper, and to act appropriately in the future.

[0041] At block, 312 the user may provide implicit feedback. In particular, remedial action taken by the user, such as slowing down, stopping, eating something, drinking water, etc., may be detected, e.g., by analyzing one or more sensor signals. For example, an accelerometer may reveal that the user slowed down or stopped moving. A heart rate monitor may reveal that the user's heart rate has lowered to acceptable levels. And so forth.

[0042] Parallel to or instead of block 312, at block 314, the user may provide explicit feedback. In particular, feedback may be received from the user as to the veracity of the determination at block 308. For example, a user may dismiss (e.g., by swiping away) a touch screen notification suggesting imminent onset of exercise-induced nausea. As another example, a user may simply ignore haptic feedback. Or, a user may explicitly acknowledge the alert raised at block 310 may selecting an "APPROVE" or "CORRECT DIAGNOSIS" button.

[0043] However feedback is detected or received from the user, at block 316, the historical data may be updated. For example, if user actions at block 312 and/or 314 suggest that the decision made at block 308 was incorrect, then a feature vector containing various data points collected at blocks 302 and 304 may be provided as a negative training example to a machine learning model.

[0044] Fig. 4 is a block diagram of an example computer system 410. Computer system 410 typically includes at least one processor 414 which communicates with a number of peripheral devices via bus subsystem 412. As used herein, the term "processor" will be understood to encompass various devices capable of performing the various functionalities attributed to the CDS system described herein such as, for example, microprocessors, FPGAs, ASICs, other similar devices, and combinations thereof. These peripheral devices may include a data retention subsystem 424, including, for example, a memory subsystem 425 and a file storage subsystem 426, user

interface output devices 420, user interface input devices 422, and a network interface subsystem 416. The input and output devices allow user interaction with computer system 410. Network interface subsystem 416 provides an interface to outside networks and is coupled to corresponding interface devices in other computer systems.

[0045] User interface input devices 422 may include a keyboard, pointing devices such as a mouse, trackball, touchpad, or graphics tablet, a scanner, a touchscreen incorporated into the display, audio input devices such as voice recognition systems, microphones, and/or other types of input devices. In general, use of the term "input device" is intended to include all possible types of devices and ways to input information into computer system 410 or onto a communication network.

[0046] User interface output devices 420 may include a display subsystem, a printer, a fax machine, or non-visual displays such as audio output devices. The display subsystem may include a cathode ray tube (CRT), a flat-panel device such as a liquid crystal display (LCD), a projection device, or some other mechanism for creating a visible image. The display subsystem may also provide non-visual display such as via audio output devices. In general, use of the term "output device" is intended to include all possible types of devices and ways to output information from computer system 410 to the user or to another machine or computer system.

[0047] Data retention system 424 stores programming and data constructs that provide the functionality of some or all of the modules described herein. For example, the data retention system 424 may include the logic to perform selected aspects of method 300, and/or to implement one or more aspects of mobile device 100 and/or computing devices 116.

[0048] These software modules are generally executed by processor 414 alone or in combination with other processors. Memory 425 used in the storage subsystem can include a number of memories including a main random access memory (RAM) 430 for storage of instructions and data during program execution, a read only memory (ROM) 432 in which fixed instructions are stored, and other types of memories such as instruction/data caches (which may additionally or alternatively be integral with at least one processor 414). A file storage subsystem 426 can provide persistent storage for program and data files, and may include a hard disk drive, a floppy disk drive along with associated removable media, a CD-ROM drive, an optical drive, or removable media cartridges. The modules implementing the functionality of certain implementations may be stored by file storage subsystem 426 in the data retention system 424, or in other machines accessible by the processor(s) 414. As used herein, the term "non-transitory computer-readable medium" will be understood to

encompass both volatile memory (*e.g.* DRAM and SRAM) and non-volatile memory (*e.g.* flash memory, magnetic storage, and optical storage) but to exclude transitory signals.

[0049] Bus subsystem 412 provides a mechanism for letting the various components and subsystems of computer system 410 communicate with each other as intended. Although bus subsystem 412 is shown schematically as a single bus, alternative implementations of the bus subsystem may use multiple busses.

[0050] Computer system 410 can be of varying types including a workstation, server, computing cluster, blade server, server farm, or any other data processing system or computing device. In some embodiments, computer system 410 may be implemented within a cloud computing environment. For example, logic 102 and/or index 120 (which stores historical data) may be implemented in whole or in part on one or more virtual machines running on hardware within (or distributed among) one or more data centers. Due to the ever-changing nature of computers and networks, the description of computer system 410 depicted in Fig. 4 is intended only as a specific example for purposes of illustrating some implementations. Many other configurations of computer system 410 are possible having more or fewer components than the computer system depicted in Fig. 4.

[0051] While several inventive embodiments have been described and illustrated herein, those of ordinary skill in the art will readily envision a variety of other means and/or structures for performing the function and/or obtaining the results and/or one or more of the advantages described herein, and each of such variations and/or modifications is deemed to be within the scope of the inventive embodiments described herein. More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the inventive teachings is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific inventive embodiments described herein. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, inventive embodiments may be practiced otherwise than as specifically described and claimed. Inventive embodiments of the present disclosure are directed to each individual feature, system, article, material, kit, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or

methods are not mutually inconsistent, is included within the inventive scope of the present disclosure.

[0052] All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms.

[0053] The indefinite articles “a” and “an,” as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean “at least one.”

[0054] The phrase “and/or,” as used herein in the specification and in the claims, should be understood to mean “either or both” of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with “and/or” should be construed in the same fashion, i.e., “one or more” of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the “and/or” clause, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, a reference to “A and/or B”, when used in conjunction with open-ended language such as “comprising” can refer, in one embodiment, to A only (optionally including elements other than B); in another embodiment, to B only (optionally including elements other than A); in yet another embodiment, to both A and B (optionally including other elements); etc.

[0055] As used herein in the specification and in the claims, “or” should be understood to have the same meaning as “and/or” as defined above. For example, when separating items in a list, “or” or “and/or” shall be interpreted as being inclusive, i.e., the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as “only one of” or “exactly one of,” or, when used in the claims, “consisting of,” will refer to the inclusion of exactly one element of a number or list of elements. In general, the term “or” as used herein shall only be interpreted as indicating exclusive alternatives (i.e. “one or the other but not both”) when preceded by terms of exclusivity, such as “either,” “one of,” “only one of,” or “exactly one of.” “Consisting essentially of,” when used in the claims, shall have its ordinary meaning as used in the field of patent law.

[0056] As used herein in the specification and in the claims, the phrase “at least one,” in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily including

at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifically identified within the list of elements to which the phrase “at least one” refers, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, “at least one of A and B” (or, equivalently, “at least one of A or B,” or, equivalently “at least one of A and/or B”) can refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including elements other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including elements other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other elements); etc.

[0057] It should also be understood that, unless clearly indicated to the contrary, in any methods claimed herein that include more than one step or act, the order of the steps or acts of the method is not necessarily limited to the order in which the steps or acts of the method are recited.

[0058] In the claims, as well as in the specification above, all transitional phrases such as “comprising,” “including,” “carrying,” “having,” “containing,” “involving,” “holding,” “composed of,” and the like are to be understood to be open-ended, i.e., to mean including but not limited to. Only the transitional phrases “consisting of” and “consisting essentially of” shall be closed or semi-closed transitional phrases, respectively, as set forth in the United States Patent Office Manual of Patent Examining Procedures, Section 2111.03. It should be understood that certain expressions and reference signs used in the claims pursuant to Rule 6.2(b) of the Patent Cooperation Treaty (“PCT”) do not limit the scope

CLAIMS

What is claimed is:

1. A computer-implemented method, comprising:
receiving (302), by one or more processors (102), one or more signals generated by one or more sensors (114) of one or more mobile computing devices (100) carried by a user (118) engaging in a physical activity, wherein the one or more signals are indicative of one or more health parameters of the user;
comparing (306), by the one or more processors, the one or more signals with historical data associated with engagement by one or more users in one or more physical activities;
determining (308), by the one or more processors based on the comparing, that the user likely will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions; and
raising (310), by the one or more processors, an alert to be provided to the user to take one or more remedial actions in response to the determining.
2. The computer-implemented method of claim 1, wherein the comparing comprises providing, as inputs to a machine learning model, data indicative of the one or more signals from the one or more sensors.
3. The computer-implemented method of claim 2, wherein the determining is based on a classification provided by the machine learning model.
4. The computer-implemented method of claim 1, wherein the determining comprises:
calculating, based on the comparing, a likelihood that the user will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions; and
determining that the likelihood satisfies a predetermined threshold.
5. The computer-implemented method of claim 1, wherein the historical data includes personal historical data associated with prior performance of the physical activity by the user.
6. The computer-implemented method of claim 1, wherein the historical data includes aggregate historical data associated with prior performance of the physical activity by a plurality of users.
7. The computer-implemented method of claim 1, wherein the historical data includes personal historical data associated with prior performance by the user of another physical activity different than the physical activity.

8. The computer-implemented method of claim 1, wherein the historical data includes aggregate historical data associated with prior performance by a plurality of users of one or more other physical activities different than the physical activity.

9. The computer-implemented method of claim 1, wherein the one or more sensors include an accelerometer.

10. The computer-implemented method of claim 1, wherein the one or more sensors include a heart rate monitor.

11. The computer-implemented method of claim 1, wherein the one or more sensors include a position coordinate sensor.

12. The computer-implemented method of claim 1, wherein the one or more sensors include a sweat sensor.

13. The computer-implemented method of claim 1, further comprising:
receiving (314), by the one or more processors, feedback from the user, the feedback indicative of whether the user accepted or rejected the alert; and
updating (316), by the one or more processors, the historical data based on the feedback and the one or more signals.

14. The computer-implemented method of claim 1, further comprising:
detecting (312), by the one or more processors based on one or more subsequent signals from the one or more sensors, that the user took remedial action; and
updating (316), by the one or more processors, the historical data based on the detecting.

15. The computer-implemented method of claim 1, further comprising:
receiving, by the one or more processors, unsolicited input from the user, the unsolicited input indicative of exercise nausea the user is experiencing or expects to experience;
in response to the unsolicited input, polling, by the one or more processors, the one or more sensors for one or more additional signals indicative of one or more health parameters of the user;
and
updating, by the one or more processors, the historical data based on the unsolicited input and the one or more additional signals.

16. A wearable computing device, comprising:
one or more sensors (114) configured to measure one or more health parameters of a user (118) wearing the wearable computing device;
one or more input components (106); and
logic (102) operably coupled with the one or more sensors and the one or more input components, the logic to:
receive, via the one or more input components, unsolicited input from the user while the user engages in a physical activity, the unsolicited input indicative of exercise nausea the user is experiencing or expects to experience;
in response to the unsolicited input, poll the one or more sensors for one or more signals indicative of the one or more health parameters of the user when the user provided the unsolicited input; and
update historical data associated with engagement by one or more users in one or more physical activities based on the unsolicited input and the one or more signals polled from the one or more sensors.

17. The wearable computing device of claim 16, wherein the logic is further configured to:

receive one or more additional signals generated by the one or more sensors, wherein the one or more signals are indicative of one or more health parameters of the user while the user engages in a physical activity;
compare the one or more signals with aggregate historical data associated with engagement by one or more users in one or more physical activities;
determine, based on the comparison, that the user likely will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions; and
raise an alert to be provided to the user to take one or more remedial actions in response to the determination that the user likely will experience nausea.

18. The wearable computing device of claim 17, wherein the logic is further configured to provide, as inputs to a machine learning model, data indicative of the one or more signals from the one or more sensors.

19. The wearable computing device of claim 18, wherein the determination that the user likely will experience nausea is based on a classification provided by the machine learning model.

20. The wearable computing device of claim 17, wherein the logic is further configured to:

calculate a likelihood that the user will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions; and
determine that the likelihood satisfies a predetermined threshold.

21. The wearable computing device of claim 17, wherein the historical data includes personal historical data associated with prior performance of the physical activity by the user.

22. The wearable computing device of claim 17, wherein the historical data includes aggregate historical data associated with prior performance of the physical activity by a plurality of users.

23. The wearable computing device of claim 17, wherein the historical data includes historical data associated with prior performance by one or more users of another physical activity different than the physical activity engaged in by the user.

24. The wearable computing device of claim 17, wherein the one or more sensors include an accelerometer.

25. The wearable computing device of claim 17, wherein the one or more sensors include a heart rate monitor.

26. The wearable computing device of claim 17, wherein the one or more sensors include a position coordinate sensor.

27. The wearable computing device of claim 17, wherein the one or more sensors include a sweat sensor.

28. The wearable computing device of claim 17, wherein the logic is further configured to:

receive feedback from the user, the feedback indicative of whether the user accepted or rejected the alert; and

update the historical data based on the feedback and the one or more signals.

29. The wearable computing device of claim 17, wherein the logic is further configured to:

detect, based on one or more subsequent signals from the one or more sensors, that the user took remedial action; and

update the historical data in response to the detected remedial action.

30. At least one non-transitory computer-readable medium comprising instructions that, in response to execution of the instructions by one or more processors, cause the one or more processors to perform the following operations:

receiving (302) one or more signals generated by one or more sensors (114) of one or more mobile computing devices (100) carried by a user (118) engaging in a physical activity, wherein the one or more signals are indicative of one or more health parameters of the user;

comparing (306) the one or more signals with historical data associated with engagement by one or more users in one or more physical activities;

determining (308), based on the comparing, that the user likely will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions; and

raising (310) an alert to be provided to the user to take one or more remedial actions in response to the determining.

31. The at least one non-transitory computer-readable medium of claim 30, wherein the comparing comprises providing, as inputs to a machine learning model, data indicative of the one or more signals from the one or more sensors.

32. The at least one non-transitory computer-readable medium of claim 31, wherein the determining is based on a classification provided by the machine learning model.

33. The at least one non-transitory computer-readable medium of claim 30, wherein the determining comprises:

calculating, based on the comparing, a likelihood that the user will experience nausea if the user continues engaging in the physical activity without taking one or more remedial actions; and
determining that the likelihood satisfies a predetermined threshold.

34. The at least one non-transitory computer-readable medium of claim 30, wherein the historical data includes personal historical data associated with prior performance of the physical activity by the user.

35. The at least one non-transitory computer-readable medium of claim 30, wherein the historical data includes aggregate historical data associated with prior performance of the physical activity by a plurality of users.

36. The at least one non-transitory computer-readable medium of claim 30, wherein the historical data includes personal historical data associated with prior performance by the user of another physical activity different than the physical activity.

37. The at least one non-transitory computer-readable medium of claim 30, wherein the historical data includes aggregate historical data associated with prior performance by a plurality of users of one or more other physical activities different than the physical activity.

38. The at least one non-transitory computer-readable medium of claim 30, wherein the one or more sensors include an accelerometer.

39. The at least one non-transitory computer-readable medium of claim 30, wherein the one or more sensors include a heart rate monitor.

40. The at least one non-transitory computer-readable medium of claim 30, wherein the one or more sensors include a position coordinate sensor.

41. The at least one non-transitory computer-readable medium of claim 30, wherein the one or more sensors include a sweat sensor.

42. The at least one non-transitory computer-readable medium of claim 30, further comprising instructions for:

receiving (314) feedback from the user, the feedback indicative of whether the user accepted or rejected the alert; and

updating (316) the historical data based on the feedback and the one or more signals.

43. The at least one non-transitory computer-readable medium of claim 30, further comprising instructions for:

detecting (312), based on one or more subsequent signals from the one or more sensors, that the user took remedial action; and

updating (316) the historical data based on the detecting.

44. The at least one non-transitory computer-readable medium of claim 30, further comprising instructions for:

receiving unsolicited input from the user, the unsolicited input indicative of exercise nausea the user is experiencing or expects to experience;

in response to the unsolicited input, polling the one or more sensors for one or more additional signals indicative of one or more health parameters of the user; and

updating the historical data based on the unsolicited input and the one or more additional signals.

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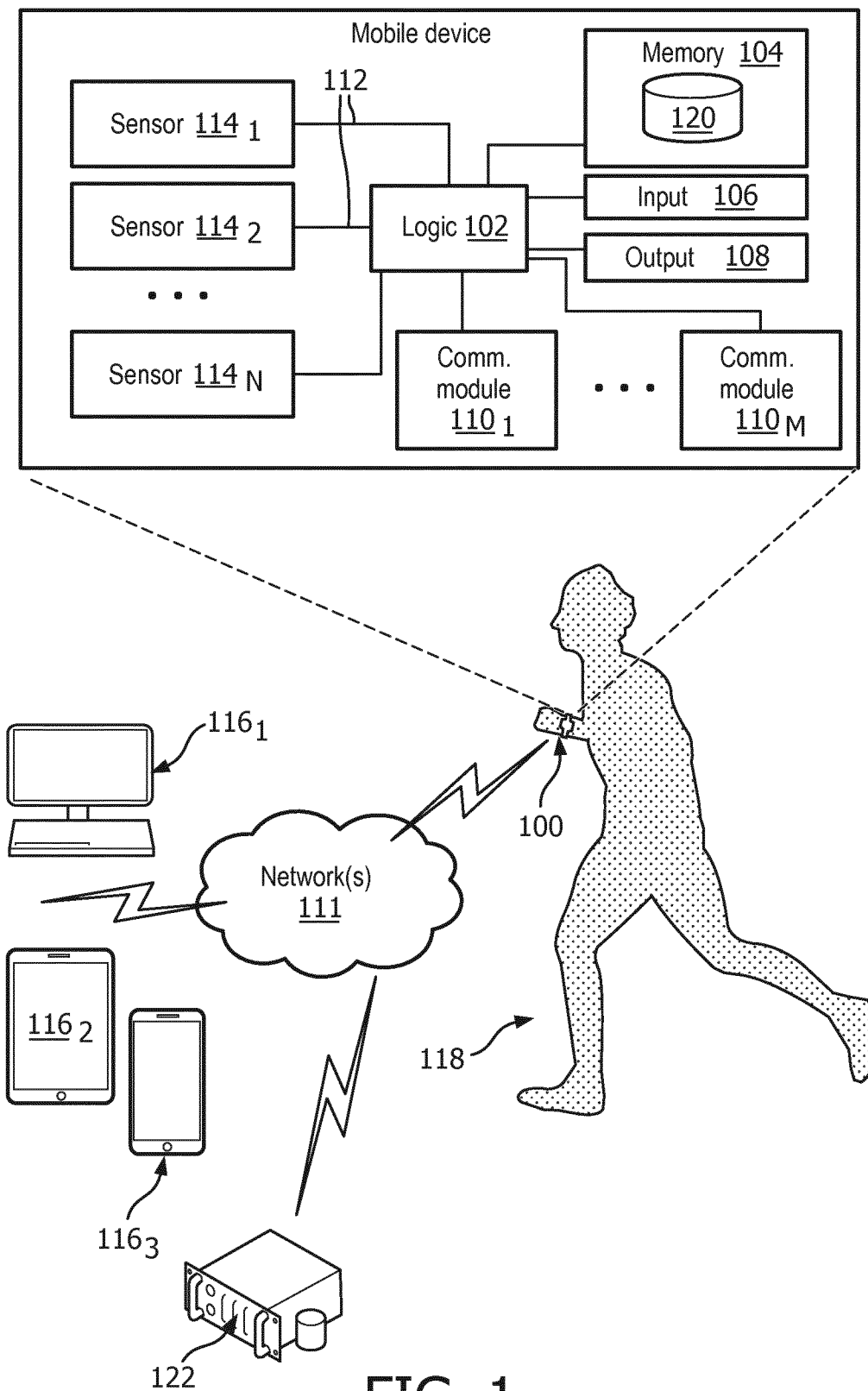


FIG. 1

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Keller Index of Nausea

Alterations in affect and behaviors	Distress	Physiological Alterations
Decrease in activity	Restlessness	Increase respiratory rate
Puts hand over mouth	Crying	Loss of appetite
Puts hand over stomach	Nausea facial expression	Vomiting
Nausea posture/positioning	Irritable/fussy	Retching/gagging
Refuses oral fluids		Cold sweating
		Skin feels cold to touch
		Changes in skin colour (pallor or flushing)
		Drooling/salivation
		Frequent swallowing
		Tongue movements/ compressing or licking lips

FIG. 2

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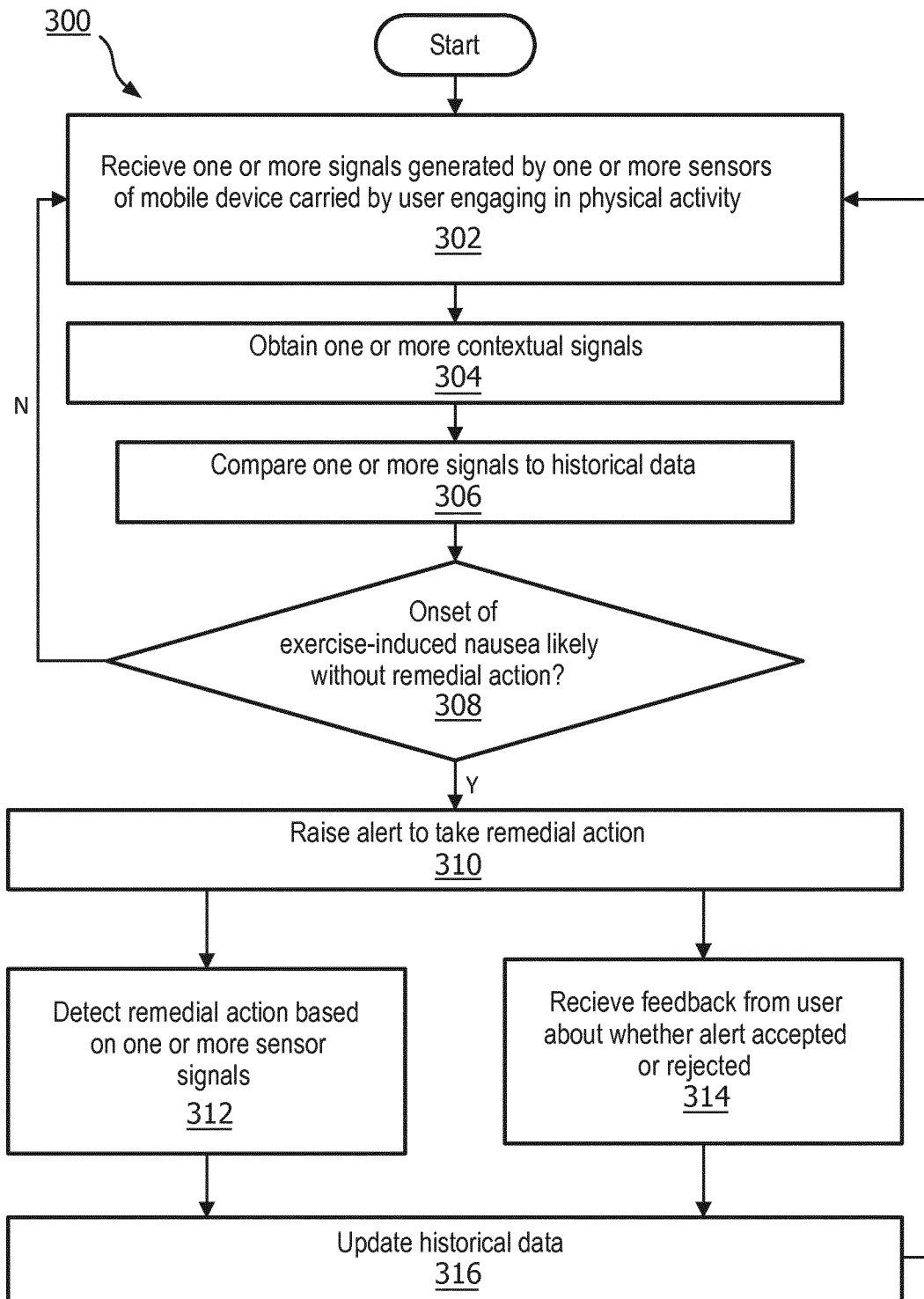


FIG. 3

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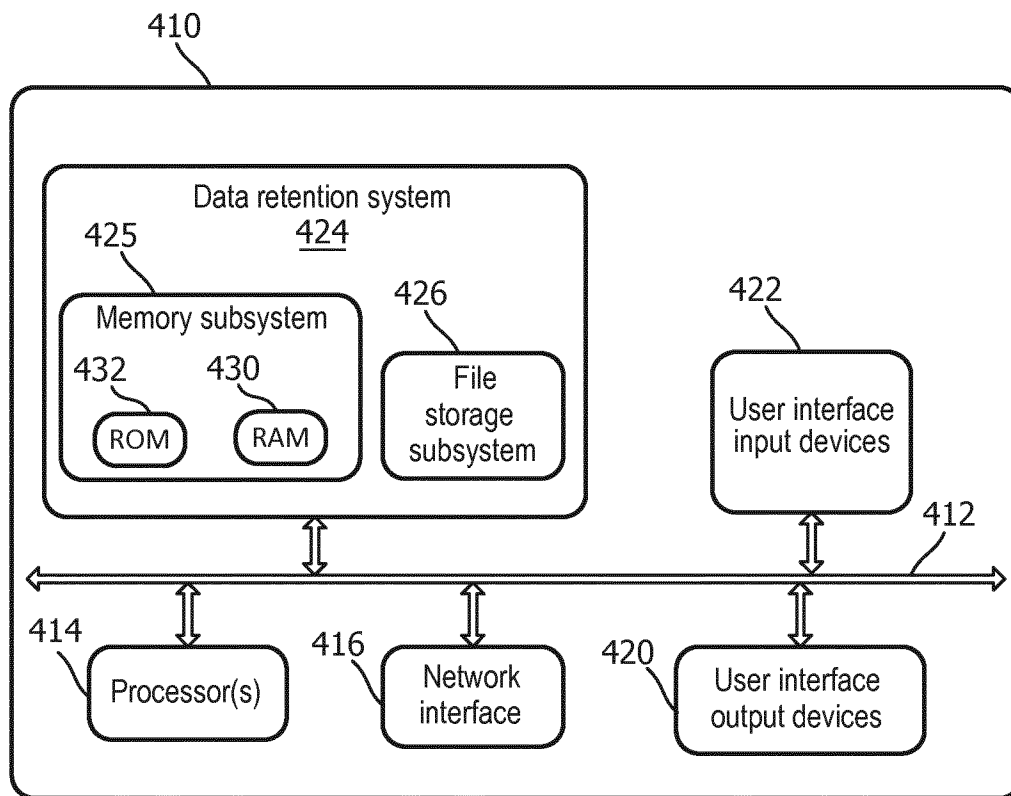


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/061527

A. CLASSIFICATION OF SUBJECT MATTER

INV. A61B5/024 A61B5/08 A61B5/11 A61B5/00
ADD.

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)

A61B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/144829 A1 (GEATZ MICHAEL W [US] ET AL) 31 July 2003 (2003-07-31) paragraph [0025] - paragraph [0036] paragraph [0043] - paragraph [0045] paragraph [0065] - paragraph [0066] -----	1-44
X A	US 2015/306486 A1 (LOGAN ROBERT J [US] ET AL) 29 October 2015 (2015-10-29) abstract paragraph [0008] - paragraph [0009] paragraph [0046] - paragraph [0049] paragraph [0082] - paragraph [0083] paragraph [0093] - paragraph [0094] ----- -/-	1,4-11, 30,33-40 17,24-26



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

7 August 2017

Date of mailing of the international search report

14/08/2017

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2017/061527

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 312 358 A (BARNEY GEORGE M) 26 January 1982 (1982-01-26)	1,5,7,8, 10,30, 34,36, 37,39
A	column 4, line 17 - line 23 column 7, line 48 - column 8, line 61 column 9, line 24 - line 61 column 12, line 47 - line 54 -----	17,21, 23,25
X	J. Heikenfeld: "Sweat Sensors Will Change How Wearables Track Your Health - IEEE Spectrum", 22 October 2014 (2014-10-22), XP055156230, Retrieved from the Internet: URL: http://spectrum.ieee.org/biomedical/di agnostics/sweat-sensors-will-change-how-we arables-track-your-health [retrieved on 2014-12-02] page 1, last par. page 4, first par. page 5, last par. -----	1,30

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International application No

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