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(54) CONTROLLING A TACTILE BREATHING GUIDANCE DEVICE

(57) A mechanism for controlling the operation of a tactile breathing guidance device. A sensor signal that carries a measure of force applied by an individual to the tactile breathing guidance device is received. A timer is started responsive to the presence of an indicator that the force applied by the individual to the tactile breathing guidance device is greater than a predetermined force threshold. The operation of the tactile breathing guidance device is controlled responsive to the sensor signal and the value of the timer.

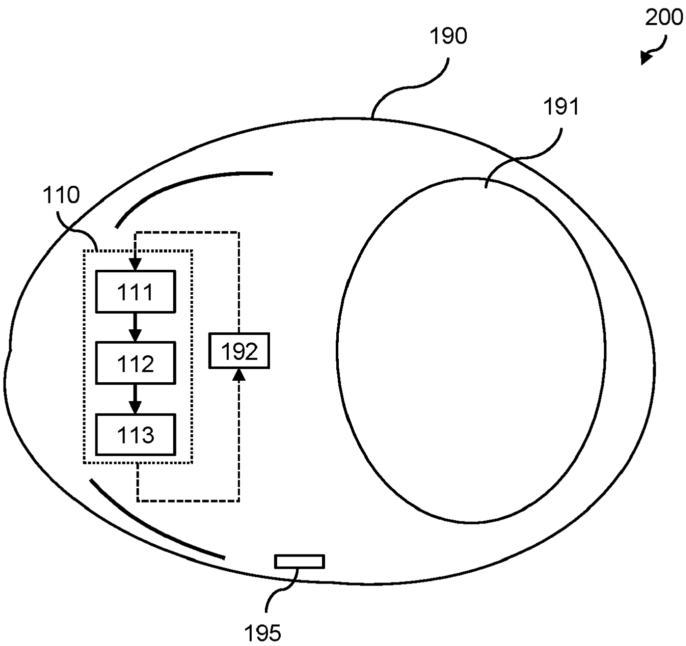

FIG. 2

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to the field of breathing guidance devices, and in particular, those that provide breathing guidance using tactile mechanisms.

BACKGROUND OF THE INVENTION

[0002] A slow and regular breathing action is considered beneficial for relaxation. More specifically, research has shown that paced or guided breathing leads to a physiological effect or outcome in humans/mammals, including reduced blood pressure and improved oxygenation of blood. One particularly useful use-case scenario for providing paced/guided breathing is to encourage or aid in falling asleep. More particularly, the physiological changes in an individual that result from paced/guided breathing are similar to those that occur whilst the individual is falling asleep.

[0003] There are a number of available breathing guidance devices that aim to encourage paced or guided breathing, including mobile phone applications or similar. However, a particularly promising device is a tactile breathing guidance device, which provides a tactile (i.e., physically moving) output for an individual. The tactile output guides the breathing of the user, e.g., by moving according to a desired breathing pattern. The individual thereby touches/engages with the tactile breathing guidance device to feel the tactile output and be guided in their breathing.

[0004] One example device is a guided breathing hugging pillow. The surface of the pillow can fluctuate up and down (e.g., by inflating/deflating an airbag) to simulate a breathing pattern for the individual. The individual can feel and follow this pattern to control their breathing by tactile sensing while touching the pillow.

[0005] There is an ongoing desire to improve the effectiveness of a tactile breathing guidance device.

SUMMARY OF THE INVENTION

[0006] The invention is defined by the claims.

[0007] According to examples in accordance with an aspect of the invention, there is provided a control system for controlling the operation of a tactile breathing guidance device configured to provide tactile guidance of breathing for an individual.

[0008] The control system comprises: an input interface configured to receive a sensor signal that carries a measure of a force applied by the individual to the tactile breathing guidance device; an output interface for communicating with the tactile breathing guidance device; and a data processor communicatively coupled to the input interface and configured to start a timer responsive to the presence of an indicator that the force applied by the individual to the tactile breathing guidance device is greater than a predetermined force threshold and control, via the output interface, the operation of the tactile breathing guidance device responsive to the sensor signal and the value of the timer.

[0009] The present disclosure provides an approach for controlling a tactile breathing guidance device response to a measure of force applied by an individual to the tactile breathing guidance device. It has been recognized that a level of force (i.e., an amount of force or measure of force) indicates a level of engagement between the individual and the tactile breathing guidance device. Changes in the level of engagement can be used to control the tactile breathing guidance device.

[0010] More particularly, it has been recognized that a tactile breathing guidance device should have continued and solid contact with the individual to function properly, i.e., at least a minimum level of force. However, during a "falling asleep" phase (i.e., whilst the individual is falling asleep) the individual may lose, reduce or otherwise change an amount of force that they apply to the tactile breathing guidance device. If contact is loss, the individual will not be able to sense the surface fluctuation of the device so not be able to follow the guided breathing pattern. Similarly, if a force is reduced, then the guided breathing pattern will be less apparent to the individual, e.g., they may unintentionally miss or skip a breathing step. This would lead to less effective breath control of the individual.

[0011] The proposed approach facilitates a mechanism for overcoming these issues, by controlling the operation of the tactile breathing guidance device responsive to a measure of force. This can allow, for instance, the tactile breathing guidance device to adapt to an applied measure of force, to alert the individual when the force is too low and/or stop providing a tactile output if the force is too low (thereby saving power or battery-life if appropriate).

[0012] The measure of the force has a categorical or continuous (e.g., numeric) data format in order to facilitate distinguishing between at least three different levels of force applied by the individual to the tactile breathing guidance device. Thus, the measure of the force may provide a numeric measure of the force or a categorical measure of the force.

[0013] The use of a value of a timer advantageously allows different control strategies to be employed for different stages of the breathing guidance program, e.g., to reflect different expected stages of sleep. This provides greater flexibility in controlling the operation of the tactile breathing control device and adaptation to specific sleep stages.

[0014] In preferred examples, the data processor is configured to control, via the output interface, the operation of the tactile breathing guidance device responsive to the measure of force carried by the sensor signal. In preferred examples, the data processor is configured to control, via the output interface, the operation of the tactile breathing guidance device responsive to the outcome of one or more comparisons between the measure of force carried by the sensor signal and a predetermined force threshold.

[0015] In some examples, the data processor is configured to: process the sensor signal to determine whether or not the force applied by the individual is greater than the predetermined force threshold; and generate the indicator that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold responsive to determining that the force applied by the individual is greater than the predetermined force threshold. Thus, the sensor signal may be monitored and used to initiate the timer.

[0016] In some examples, the input interface is configured to receive a first user input signal that carries the indicator that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold; and the data processor is configured to, responsive to receiving the indicator that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold, determine the force threshold responsive to the measure of the force carried by the sensor signal. This allows an individual or other user to trigger the starting of the timer, which can avoid the need to generate/monitor the sensor signal before use of the tactile breathing guidance device is required, thereby saving power.

[0017] The first user input signal is preferably a signal that is not affected or controlled by the sensor signal, i.e., is a separate signal. For instance, the first user input signal may be an input signal received at a separate user input interface such as a touchscreen or the like.

[0018] Optionally, the data processor is configured to control the tactile breathing guidance device to initiate tactile guidance of breathing responsive to the presence of the indicator that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold. Thus, the timer and tactile guidance may be initiated at a same time.

[0019] The data processor may be configured to, responsive to the value of the timer indicating that a time since starting the timer falls within a first time range and the measure of force carried by the sensor signal indicating that the force applied by the individual to the tactile breathing guidance device is lower than the predetermined force threshold, control the tactile breathing guidance device to provide one or more user-perceptible feedback alerts.

[0020] This approach alerts the individual to a potential loss of tactile guidance (on their behalf). The assumption here is the individual has not fallen into sleep, but has already loses contact with the device. This approach can, for instance, encourage the individual to continue to contact the device for guided breathing to aid them in falling asleep.

[0021] The lower bound of the first time range is 0.

[0022] Preferably, the one or more user-perceptible feedback alerts comprises at least one audible alarm.

[0023] In some examples, the data processor is configured to control the tactile breathing guidance device to provide the one or more user-perceptible feedback alerts by: controlling the tactile breathing guidance device to iteratively provide a user-perceptible feedback alert only whilst the value of the timer indicating that a time since starting the timer falls within a first time range and the measure of force carried by the sensor signal indicating that the force applied by the individual to the tactile breathing guidance device continues to be lower than the predetermined force threshold.

[0024] Thus, the data processor may be configured to control the tactile breathing guidance device to stop providing the one or more user-perceptible feedback alerts responsive to the value of the timer indicating that a time since starting the timer no longer within a first time range and/or the measure of force carried by the sensor signal indicating that the force applied by the individual to the tactile breathing guidance device no longer continues to be lower than the predetermined force threshold.

[0025] This approach avoids or reduces disruption to an individual one they have regained sufficient contact with the device.

[0026] In some examples, the data processor is further configured to: monitor the number of user-perceptible alerts provided by the tactile breathing guidance device; and responsive to the number of user-perceptible alerts reaching a predetermined alert threshold, prevent the generation of any further user-perceptible alerts. This approach prevents potential further disruption to the individual if they ignore the alerts, as this may indicate that they have already fallen asleep and no longer require the tactile breathing guidance. This approach also saves power (for generating the alerts).

[0027] In some examples, the data processor is configured to, responsive to the number of user-perceptible alerts reaching a predetermined alert threshold and the force applied by the individual to the tactile breathing guidance device is still lower than the predetermined force threshold: set the value of the timer to a value that indicates that a time since starting the timer is equal to or greater than an upper bound of the first time range; and/or change the upper bound of the first time range to be equal to the time elapsed since starting the timer. These provide suitable examples of approaches for avoiding the continued generation of user-perceptible alerts.

[0028] In some examples, the tactile breathing guidance device comprises a controllable actuator for providing the tactile guidance of breathing for an individual; and the data processor is configured to, responsive to the value of the timer indicating that a time since starting the timer falls within a first time range and the measure of force carried by the sensor signal indicating that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold, adjust, via the output interface, a maximum amplitude of movement by the controllable actuator responsive to the measure of force carried by the sensor signal.

[0029] In some examples, the data processor is configured to reduce the maximum amplitude of movement by the controllable actuator responsive to the measure of force indicating an increased force applied by the individual to the tactile breathing guidance device.

[0030] Optionally, the tactile breathing guidance device comprises a controllable actuator for providing the tactile guidance of breathing for an individual; and the data processor is configured to, responsive to the value of the timer indicating that a time since starting the timer falls within a second time range: adjust, via the output interface, a maximum amplitude of movement by the controllable actuator responsive to the measure of force carried by the sensor signal. In one example, no user-perceptible alerts will be generated via the output interface during the second time range.

[0031] In some examples, the tactile breathing guidance device comprises a controllable actuator for providing the tactile guidance of breathing for an individual; and the data processor is configured to, responsive to the value of the timer indicating that a time since starting the timer falls within a third time range and the measure of force carried by the sensor signal indicating that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold, reduce, via the output interface, a maximum amplitude of movement by the controllable actuator responsive to the measure of force carried by the sensor signal.

[0032] A lower bound of the third time range is preferably equal to an upper bound of the second time range. If the second time range is not present, but the first time range is present, the lower bound of the third time range may be equal to the upper bound of the first time range.

[0033] The data processor may be configured to, responsive to the value of the timer indicating that a time since starting the timer not falling in any other time range, control the device to stop the tactile guidance. For example, when the value of the timer exceeds the third time range, the data processor will control the device to stop the tactile guidance (turn off the operation of the tactile breathing guidance device, for example).

[0034] In at least one example, the tactile breathing guidance device comprises a controllable actuator for providing the tactile guidance of breathing for an individual; and the data processor is configured to control, via the output interface, a maximum amplitude of movement by the controllable actuator responsive to the sensor signal.

[0035] There is also provided a feedback system for controlling the operation of a tactile breathing guidance device for providing tactile guidance of breathing for an individual. The feedback system comprises: the control system previously described; and a force sensing system communicatively coupled to the input interface of the control system and configured to generate the sensor signal responsive to an amount of force applied by the individual to the tactile breathing guidance device.

[0036] In preferred examples, the force sensing system comprises a flex sensor configured to change the sensor signal responsive to an amount of flexing and/or bending of the flex sensor.

[0037] The force sensing system may be configured to change the sensor signal responsive to an amount of hugging or squeezing applied by the individual to the tactile breathing guidance device.

[0038] The predetermined force threshold may represent a measure of force that is greater than the value of a measure of force applied when the individual touches (but has not attempted to deform) the tactile breathing guidance device. Thus, the predetermined force threshold may be greater than a touch threshold that indicates the individual has touched or begun to touch the tactile breathing control device.

[0039] Put another way, the force threshold may be a value of the measure of force that, if applied to the tactile breathing guidance device, would deform the tactile breathing guidance device. This is distinguished from a touch threshold which represents a value of the measure of force that, if applied to the tactile breathing guidance device, would not deform the tactile breathing guidance device but would indicate a touching of the tactile breathing guidance device by the individual.

[0040] There is also provided a tactile breathing guidance system comprising: a tactile breathing guidance device configured to provide tactile guidance of breathing to an individual; and the feedback system previously describe. The force sensing system of the feedback system is carried by the tactile breathing guidance device; and the tactile breathing guidance device is communicatively coupled to the output interface of the control system of the feedback system.

[0041] There is also provided a computer-implemented method for controlling the operation of a tactile breathing guidance device for providing tactile guidance of breathing for an individual, the computer-implemented method comprising: receiving a sensor signal that carries a measure of a force applied by the individual to the tactile breathing guidance device; and controlling the operation of the tactile breathing guidance device responsive to the sensor signal.

[0042] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] For a better understanding of the invention, and to show more clearly how it may be carried into effect, reference will now be made, by way of example only, to the accompanying drawings, in which:

Fig. 1 illustrates a tactile breathing guidance system in which embodiments of the invention can be employed;

Fig. 2 illustrates another tactile breathing guidance system in which embodiments of the invention can be employed;

Fig. 3 is a flowchart illustrating a method according to an embodiment; and

Fig. 4 illustrates a portion of a tactile breathing guidance system.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0044] The invention will be described with reference to the Figs

[0045] It should be understood that the detailed description and specific examples, while indicating exemplary embodiments of the apparatus, systems and methods, are intended for purposes of illustration only and are not intended to limit the scope of the invention. These and other features, aspects, and advantages of the apparatus, systems and methods of the present invention will become better understood from the following description, appended claims, and accompanying drawings. It should be understood that the Figs are merely schematic and are not drawn to scale. It should also be understood that the same reference numerals are used throughout the Figs to indicate the same or similar parts.

[0046] The invention provides a mechanism for controlling the operation of a tactile breathing guidance device. A sensor signal that carries a measure of force applied by an individual to the tactile breathing guidance device is received. A timer is started responsive to the presence of an indicator that the force applied by the individual to the tactile breathing guidance device is greater than a predetermined force threshold. The operation of the tactile breathing guidance device is controlled responsive to the sensor signal and the value of the timer.

[0047] Herein proposed approaches are based on the realization that the amount of force applied by an individual influences whether or not that individual is able to perceive the tactile breathing guidance provided by the device. By controlling the device responsive to the measure of force applied, it is possible to control the device to provide guidance when most appropriate to the individual and/or alert the individual when they are predicted to not be able to perceive the guidance.

[0048] Embodiments are particularly useful in sleeping environments, e.g., to encourage an individual to fall asleep. This is because, in such environments, it is natural or common for the individual to hug - and therefore apply force to - an object (e.g., a pillow or the like), such that a tactile breathing guidance device is able to act as the hugged object.

[0049] Fig. 1 illustrates a tactile breathing guidance system 100 in which embodiments of the invention can be employed, for improved contextual understanding.

[0050] The tactile breathing guidance system 100 comprises a tactile breathing guidance device 190 (the "device") and a feedback system. The feedback system is itself formed of a control system 110 and a force sensing system 120.

[0051] The tactile breathing guidance device 190 is a device configured to provide tactile guidance of breathing for an individual. Thus, the tactile breathing guidance device comprises a moveable member that is able to move to guide the breathing of an individual. For instance, the moveable member may be controllable to move at a desired breathing rate, pace or pattern for the individual. The desired breathing rate, pace or pattern may be according to a breathing guidance control process or program.

[0052] Typically, a tactile breathing guidance device includes a controllable actuator 191 or electro-mechanic module. The actuator 191 can be controlled to move to provide the tactile guidance to the individual, i.e., provide a tactile output to the individual. The actuator 191 thereby acts as a movable member. For instance, the actuator 191 may move or fluctuate a surface of the tactile breathing guidance device according to a desired breathing rate and/or pattern, to guide the individual to follow the breathing rate and/or pattern.

[0053] One example of an actuator 191 is an airbag with controllable inflation and deflation. Another example is a piston-based system for providing tactile feedback. Yet another example is a motor-driven paddle.

[0054] Approaches for performing tactile breathing guidance are well known in the art and are not herein described for the sake of conciseness. Example approaches are described by Pinna, Gian Domenico, et al. "Effect of paced breathing on ventilatory and cardiovascular variability parameters during short-term investigations of autonomic function." American Journal of Physiology-Heart and Circulatory Physiology 290.1 (2006): H424-H433 or Laborde, Sylvain, et al. "Slow-paced breathing: influence of Inhalation/Exhalation ratio and of respiratory pauses on cardiac vagal activity." Sustainability 13.14 (2021): 7775.

[0055] The tactile breathing guidance device may be formed as a (huggable) pillow or cushion, e.g., with a soft surface material. This is natural for an individual to hug or squeeze when preparing to sleep or when falling asleep, to ensure that the tactile breathing guidance is able to provide the tactile feedback in a natural manner.

[0056] However, this is not essential. In another example, the tactile breathing guidance device may be a handheld device that can be squeezed or held in the hand, e.g., a soft toy, stress ball or the like.

[0057] The tactile breathing guidance device may also comprise a device control system 192, configured to control the operation of the controllable actuator 191. The device control system 192 may, for instance, comprise a microcontroller and/or other control logic for controlling the operation of the controllable actuator 191.

[0058] The control system 110 is configured to control the operation of the tactile breathing guidance device.

[0059] The control system 110 comprises an input interface 111, a data processor 112 and an output interface 113. The data processor 112 of the control system 110 is configured to control the operation of the tactile breathing guidance device 190 via the output interface 113.

[0060] Accordingly, the output interface 113 is communicatively coupled to the tactile breathing guidance device to control the operation thereof. In particular, the output interface 113 may be communicatively coupled to the device control system 192, to control the operation of the tactile breathing guidance device using the capabilities of the device control system 192, e.g., using a control signal Sc. For instance, the control system may control the operation of the device control system 192 by providing instructions for execution by the device control system.

[0061] The communication between the output interface 113 and the tactile breathing guidance device 190 may be wired or wireless. Suitable wireless communication protocols that may be used to communicate with the tactile breathing guidance device 190 include an infrared link, Zigbee, Bluetooth, a wireless local area network protocol such as in accordance with the IEEE 802.11 standards, a 2G, 3G, 4G or 5G telecommunication protocol, and so on. Other formats will be readily apparent to the person skilled in the art.

[0062] The input interface 111 is configured to receive a sensor signal Ss that carries a measure of a force applied by the individual to the tactile breathing guidance device. Thus, the sensor signal encodes or carries the measure of force in a computer-readable manner.

[0063] The measure of the force has a categorical or continuous (e.g. numeric) data format, in order to facilitate distinguishing between at least three different levels of force applied by the individual to the tactile breathing guidance device. Thus, the measure of the force may provide a numeric measure of the force or a categorical measure of the force. A binary data format is unable to provide a measure of a force.

[0064] The sensor signal Ss is generated by the force sensing system 120. Any suitable force sensing system that is capable of generating a measure of force applied by the individual to the device 190 may be used, and a number of suitable examples are provided later in this disclosure.

[0065] The communication between the input interface 111 and the force sensor system 120 may be wired or wireless. Suitable wireless communication protocols that may be used to communicate between the two elements include an infrared link, Zigbee, Bluetooth, a wireless local area network protocol such as in accordance with the IEEE 802.11 standards, a 2G, 3G, 4G or 5G telecommunication protocol, and so on. Other formats will be readily apparent to the person skilled in the art.

[0066] In preferred examples, the sensor signal Ss is responsive to an amount of hugging or squeezing applied by the individual to the tactile breathing guidance device. More particularly, the measure of force may be a measure of an amount of squeezing applied to the device 190 by the individual.

[0067] The sensor signal Ss may be responsive to a measure of the deformation of the tactile breathing guidance device by the individual. The application of a non-zero force to the tactile breathing guidance device causes a deformation to the tactile breathing guidance device.

[0068] The data processor 112 is communicatively coupled to the input interface 111. The data processor 112 is configured to control, via the output interface, the operation of the tactile breathing guidance device responsive to the sensor signal. More particularly, the data processor 112 is configured to control, via the output interface, the operation of the tactile breathing guidance device responsive to measure of force carried by the sensor signal.

[0069] Thus, the operation of the tactile breathing guidance device 190 is responsive to the measure of force applied by the individual to the tactile breathing guidance device, as measured or determined by a force sensing system 130. The measure of force is carried by the sensor signal Ss to the control system 110.

[0070] In preferred examples, the data processor 112 is configured to control, via the output interface, the operation of the tactile breathing guidance device responsive to the outcome of one or more comparisons between the measure of force carried by the sensor signal a predetermined force threshold.

[0071] A force threshold may represent a measure of force that is greater than the value of a measure of force applied when the individual touches (but has not attempted to deform) the tactile breathing guidance device. Thus, the force threshold may be greater than a touch threshold that indicates the individual has touched or begun to touch the tactile breathing control device. Put another way, the force threshold may be a value of the measure of force that, if applied to the tactile breathing guidance device, would deform the tactile breathing guidance device. This is distinguished from a touch threshold which represents a value of the measure of force that, if applied to the tactile breathing guidance device, would not deform the tactile breathing guidance device but would indicate a touching of the tactile breathing guidance device by the individual.

[0072] Various examples of how such a force threshold could be exploited are provided later in this document.

[0073] The proposed approach facilitates force-sensitive control over the operation of the tactile breathing guidance device. This can facilitate, for instance: automated initiation and/or termination of breathing guidance by the device 190; automated feedback to the individual to re-engage with the device 190 if engagement is lost; and/or automated control over the amplitude of movement for providing tactile breathing guidance (e.g., to avoid or reduce disruption and/or damage to the individual).

[0074] The control system 110 may further comprise a user interface 115, e.g., a touch-sensitive screen. This can, for instance, permit a user or individual to provide information, i.e., user input information, usable in the control of the tactile breathing guidance device 190.

[0075] The control system 110 may, for instance, be a computing device such as a mobile/cellular phone, a tablet, a laptop and/or a standalone system. Thus, the control system 110 may be a separate system to the device 190.

[0076] The tactile breathing guidance device 190 may further comprise a user output interface 195. The user output interface is configured to (controllably) generate one or more user-perceptible outputs, such as an audible alarm or alert. Embodiments may make use of the user output interface in controlling the operation of the tactile breathing guidance device.

[0077] Haynes, Alice C., et al. "A calming hug: Design and validation of a tactile aid to ease anxiety." Plos one 17.3 (2022): e0259838 discloses a tactile breathing guidance device 190 that could be used in some embodiments, as well as approaches for performing guided breathing using such a tactile breathing guidance device. Ingersoll, Evan W., and Evelyn B. Thoman. "The breathing bear: effects on respiration in premature infants." Physiology & behavior 56.5 (1994): 855-859 discloses another example of a tactile breathing guidance device.

[0078] Fig. 2 illustrates an alternative system 200 in which embodiments of the invention can be employed.

[0079] In this approach, instead of the control system 110 being formed as a separate entity to the tactile breathing guidance device 190, it is formed as an aspect of the tactile breathing guidance device. Thus, the tactile breathing guidance device comprises the control system.

[0080] In particular, the control system 110 may form an aspect of the device control system of the tactile breathing guidance device.

[0081] This approach provides an "all-in-one" or standalone system for providing tactile breathing guidance device.

[0082] A number of simple examples for controlling the tactile breathing guidance device 190 (of any system 100, 200) using the measure of force carried by the sensor signal Ss are hereafter described.

[0083] In one example, the data processor 112 is configured to process or monitor the sensor signal to identify or detect whether or not the measure of force is greater than a predetermined force threshold. Responsive to the measure of force being greater than the predetermined force threshold, the data processor 112 may be configured to control the device 190 to begin providing tactile guidance of breathing to the individual. This approach provides an automated mechanism for initiating the breathing guidance to the individual that is only performed during scenarios in which the breathing guidance is desired (e.g., as the user is going to sleep and hugging the device 190).

[0084] As yet another example, the data processor 112 may be configured to control a maximum amplitude of movement or actuation, by the controllable actuator, responsive to the measure of force carried by the sensor signal. In particular, the data processor 112 may be configured to reduce the maximum (allowable) amplitude of movement or actuation responsive to the measure of force indicating an increase in the force applied by the individual to the device 190. This approach can avoid or reduce the likelihood of discomfort or injury to the individual if they are tightly squeezing or hugging the device 190, as well as reducing a power consumption as the individual will be more sensitive to smaller movements of the actuator with increased application of force.

[0085] As yet another example, the data processor 112 may be configured to control the device 190 to generate a user-perceptible alert responsive to the measure of force falling below the predetermined force threshold. This approach encourages the individual to re-engage with the device if they lose engagement. The user-perceptible alert may, for instance, be an audible alert.

[0086] As yet another example, the data processor may be configured to start a timer responsive to the presence of an indicator that the force applied by the individual to the tactile breathing guidance device is greater than a predetermined force threshold. The data processor may then control, via the output interface, the operation of the tactile breathing guidance device responsive to the value of the timer. For instance, the data processor may be configured to terminate or end the provision of tactile guidance of breathing to the individual when the elapsed time (as indicated by the timer) reaches a certain value and/or perform different control actions for different periods or ranges of elapsed time.

[0087] Of course, a combination of these approaches can be employed in variation combinations and embodiments. Thus, these approaches thereby provide or represent basic "building blocks" for creating a method or technique for controlling a tractile breathing guidance device 190 responsive to a sensor signal carrying a measure of force applied by an individual to the device 190.

[0088] The above examples provide a number of different simple approaches for controlling the operation of the tactile breathing guidance device responsive to the measure of force. A more complex approach that incorporates one or more techniques described above is hereafter described.

[0089] Fig. 3 is a flowchart illustrating a method 300 for controlling the operation of a tactile breathing guidance device according to an embodiment. The method is performed by (the data processor of) the control system and showcases a number of possible techniques and approaches for controlling the operation of the device.

[0090] It will be appreciated that the method 300 is only performed if/when the tactile breathing guidance device is powered on. Of course, the skilled person would appreciate that, after being powered on, the tactile breathing guidance device may also perform an initialization process (e.g., to load or set parameters for use with the method). This initialization process has not been illustrated for the sake of clarity.

[0091] The method 300 comprises an initiation process 310.

[0092] The initiation process 310 comprises a step 311 of starting or initiating the performance of breathing guidance (i.e., starting/initiating tactile guidance) by the tactile breathing guidance device. Approaches for performing tactile (breathing) guidance are well-established in the art.

[0093] Two alternatives for performing the initiation process 310 are illustrated in Fig. 3. In both alternatives, step 311 is performed responsive to the presence of an indicator that the force applied by the individual to the tactile breathing guidance device is greater than a first force threshold. The two alternatives differ in how the indicator is provided or determined.

[0094] It will be appreciated that only one of the two alternatives need to be performed but that, in some embodiments, both alternatives are simultaneously performed. If either alternative executes step 311, then the initiation process 310 may terminate.

[0095] In a first alternative 310A, the initiation process comprises a step 312 of monitoring the sensor signal and determining, e.g., in a step 313, whether or not the measure of force F is greater than a predetermined force threshold F_T. In this way, if the measure of force is greater than the predetermined force threshold, then the sensor signal provides the indicator that force is greater than the predetermined force threshold.

[0096] In the first alternative 310A, responsive to the force being greater than or equal to the predetermined force threshold, step 311 is performed. Otherwise, the method reverts and iteratively repeats steps 312 and 313.

[0097] Thus, if the first alternative is performed, the sensor signal needs to be generated before the performance of tactile breathing guidance begins.

[0098] In a second alternative 310B, the initiation process comprises a step 314 of monitoring a first user input signal. The first user input signal can either carry or not carry the indicator that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold. The second alternative 310B comprises a step 315 of determining whether or not the first user input signal is carrying the indicator. Responsive to the first user input signal carrying the indicator, step 311 is performed. Otherwise, the method iteratively repeats steps 314 and 315.

[0099] Thus, if only the second alternative is performed, the sensor signal does not need to be generated or monitored before the performance of tactile breathing guidance begins. This can advantageously save power if only the second alternative is performed.

[0100] In either alternative 310A, 310B, the initiation process 310 comprises a step 319 of starting a timer (e.g., which has been initialized to 0) responsive to the presence of the indicator that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold.

[0101] The value of a timer represents an elapsed time since starting the timer. Approaches for starting and/or configuring a timer are well known in the art. In some examples, this comprises recording a current timestamp, against which future timestamps can be compared to determine an elapsed time. In other examples, starting a timer comprises beginning an automatically incrementing counter that represents the passage of time. Any timer may, for instance, be in millisecond resolution.

[0102] The value of this timer can be used to control the operation of the tactile breathing guidance device, examples of which are later described.

[0103] After performing the initiation process 310, the method 300 moves to a guidance control process 320, during which the individual is provided with tactile breathing guidance. Thus, a guided breathing program is active during the course of the guidance control process 320. In the guidance control process 320, the operation of the tactile breathing guidance device is controlled responsive to the sensor signal and the value of the timer

[0104] The guidance control process 320 comprises iteratively, continuously, or periodically checking the value of the timer, in a step 321, to determine an elapsed time T since beginning the timer (in step 319).

[0105] The elapsed time T may then be compared with one or more (predetermined) time thresholds and/or time ranges, and actions taken responsive to where the elapsed time T falls with respect to the threshold(s) or range(s).

[0106] In the illustrated example there are 4 time-stages/ranges for control. The first time range is from time zero to time Ts, where Ts is a first predetermined time threshold. The second time range is from time Ts to time Te, where Te represents a second predetermined time threshold (and is larger than Ts - and may be equal to Ts + Tbias1). The third time range is from time Te to time Toff, where Toff represents a third predetermined time threshold (and is larger than Te (if present)and Ts - and may be equal to Te + Tbias2). A fourth time range occurs when the elapsed time is greater than the third predetermined time threshold.

[0107] In some examples, one or more of these time ranges may be omitted.

[0108] The value of each predetermined time threshold may be defined by a user, e.g., via a user input interface. Alternatively, the value of each predetermined time threshold may be preset, e.g., preset in a factory or at the time of manufacture.

[0109] In some examples, the first predetermined time threshold Ts represents a normal time (e.g., for the specific individual or population of individuals) from going to bed to sleeping. Thus, the first time range represents a period during which the user is not yet asleep but is falling asleep. By way of example, the first predetermined time threshold may be a value between 10 and 30 minutes, e.g., 20 minutes (which is a typically upper limit of a time taken for an adult to fall asleep). This value may be higher for individuals with sleep-related disorders.

[0110] The second time range (e.g., between the first and second predetermined time thresholds) may represent a period during which the user has fallen asleep. It will be apparent that a lower bound of the second time range is equal to an upper bound of the first time range. In this second time range, the guided breathing program may still be active, to impact the individual unconsciously if they are already in sleep status. The second time range may, for instance, represent a period of N1 or Stage 1 sleep (also known as light sleep). The second predetermined time threshold may, for instance, be a value between 12 and 40 minutes, e.g., a value equal to the first predetermined time period plus between 3 and 10 minutes.

[0111] The third time range (e.g., between the second and third predetermined time thresholds) may represent a time period during which the user is asleep, e.g., but it may still be advantageous to gradually phase out the guided breathing program to avoid an abrupt change that is potentially possible to affect sleep status. The third predetermined time threshold may be equal to the second predetermined time period plus a value between 5 and 20 minutes. It will be apparent that a lower bound of the third time range is equal to an upper bound of the second time range.

[0112] The fourth time range (after the third predetermined time threshold) may represent a time period of deep sleep. It will be apparent that a lower bound of the fourth time range is equal to an upper bound of the third time range. In the described example, the fourth time range has no upper bound.

[0113] Each time range may be predetermined or otherwise defined in advance. Thus, each "time range" may, in practice be a "predetermined time range".

[0114] Of course, in preferred examples, any of the predetermined time thresholds or time ranges may be overridden or changed by an individual or other user (e.g., a clinician such as a sleep specialist) to suit the needs of the individual. In some instances, each predetermined time threshold and/or time range may be set by a sleep monitoring system that monitors the sleep of the individual.

[0115] Thus, the guidance control process 320 may repeatedly compare the elapsed time to the time ranges (where appropriate), e.g., by comparing the elapsed time to the predetermined time thresholds. One or more actions may be taken in response to the outcome of this comparison: e.g., taking no action, stopping the guidance control process 320, modifying the amplitude of the tactile feedback to the individual and so on.

[0116] The guidance control process 320 may comprise a step 331 of determining whether or not the elapsed time T lies within a first time range (e.g., is less than the first predetermined time threshold Ts). Responsive to a positive determination in step 331, the method moves to a step 332 of determining whether or not the (current or most recent) measure of force F is greater than the predetermined force threshold F_T.

[0117] Responsive to a positive determination in step 332, then the method may perform a step 333 of controlling the tactile breathing guidance device to provide a user-perceptible alarm, such as an audible alarm or the like. This reminds the individual to re-engage with the device (e.g., hug or squeeze the device again). The user-perceptible alarm can last for certain time for instance 3 seconds. During the alarm, if the measure of force F is not smaller than the predetermined force threshold F_T (which means the user hugs the device again), the alarm will stop. After performing step 333, the method may revert back to step 332. This procedure will repeat and last for the rest of the time of the first time range, i.e., until the elapsed time reaches the first predetermined time threshold Ts.

[0118] In some examples, the user-perceptible alarm is only provided for a predetermined number of times A_T. Thus, the method may comprise (after a positive determination in step 332) a step 334 of determining whether the number A of generated user-perceptible is greater than or equal to a predetermined alert threshold number A_T, i.e., whether the number of user-perceptible alerts provided by the tactile breathing guidance device has reached the predetermined alert threshold A_T.

[0119] If the number of times that the user-perceptible alarm has been provided is greater than the predetermined alert threshold number A_T and the measure of force F is still smaller than the force threshold F_T (which means the user is still not hugging the device again), the alarm will also stop. This is because the user may already have fallen asleep and further alarms will affect the sleep quality of the user. In this case, the guidance control process 320 will assume that the elapsed time is now in the second time range from time Ts to time Te.

[0120] Preferably, Ts will be newly set as a value Ta when the alarm stops, as the user has been assumed to be asleep at time Ta. The value Ta may be equal to the value of the current time that has elapsed since starting the timer. In particular embodiments, the second time range is changed to start from Ta and end at Te.

[0121] In sum, responsive to a positive determination in step 334, the value of the first predetermined time threshold Ts may be set to the value of the timestamp Ta in a step 335 and/or the value of the timer may be set to the value of the first predetermined time threshold or even greater than the value of the first predetermined time threshold. This prevents or stops the alarm from being issued. In other wordings, if user has no feedback after certain times of alerts during the first time range, the first time range will end and the second time range will begin directly. Alternatively, in another example, even the length of the second time range will be shortened. This means that the first time range will end and the value of the timer will be set to a certain timestamp within the second time range.

[0122] In another example, responsive to a positive determination in step 334, the method simply avoids or bypasses the step 333.

[0123] Each instance of issuing an alarm can be sent with a delay. For instance, each alarm lasts for X seconds, then stop for Y seconds before alarming again. X may be a value between 1 and 10 seconds (e.g., 3 seconds). Y may be a value between 1 and 60 second inclusively (e.g., 3 seconds, 10 seconds, or 30 seconds).

[0124] In some examples, the method also comprises a step 390 of controlling a maximum amplitude of movement by the controllable actuator (of the tactile breathing guidance device) responsive to the sensor signal, and more particularly to the measure of force. For instance, the maximum amplitude of movement may be controlled to be inversely proportional or inversely related to the measure of force. For instance, if the measure of force F is in a high force range, the amplitude of airbag can be decreased for a certain amount, to avoid large pressure and push back to user. This amplitude adjustment can be set to execute at certain frequency, for instance, every 10 seconds. Further, the maximum amplitude of movement can be adjusted based on the forces sensed at the 10th second or the average sensed value of the past 10 seconds. Step 390 may be performed after a negative determination in step 332 and/or a positive determination in step 334. After performing step 390, the method may revert back to 321. If step 390 is not included in method 300 (or after the relevant preceding step), then the method may simply revert or default to reverting back to step 321.

[0125] In some examples, step 390 may be iteratively performed after initiation of breathing guidance until the end of breathing guidance or until the system is switched off.

[0126] In more preferable examples, step 390 is iteratively or repeatedly performed whilst the value of the timer indicates that a time that has elapsed falls within the first and/or second time range.

[0127] Responsive to a negative determination in step 331, then the method moves to a step 341 of determining whether or not the elapsed time T is within the second time range (i.e., less than the second predetermined time threshold Te).

[0128] Responsive to a positive determination in step 341, then the method may perform the step 390. If this step is not included in method 300, the method may simply revert back to step 321. More particularly, responsive to a positive determination in step 341, then the method 300 is configured to avoid or prevent the generation of any user-perceptible alerts whilst continuing the tactile breathing guidance.

[0129] Responsive to a negative determination in step 341, then the method then the method moves to a step 351 of determining whether or not the elapsed time T is within the third time range, e.g., is less than the third predetermined time threshold Toff.

[0130] Responsive to a negative determination in step 351, then the method may end the guidance control process 320 and optionally switch the device off in a step 360.

[0131] In some examples, step 360 also comprises preventing the guidance control process 320 from reinitializing until a predetermined delay time period has elapsed. This approach can, for instance, avoid the breathing guidance from undesirably restarting responsive to movements in the individual's sleep (e.g., rolling onto the device), which may disturb/awaken the individual and/or waste power/energy. Of course, this function may be overridden, e.g., by the user providing an override indication via a user input interface.

[0132] Responsive to a positive determination in step 351, then the method may gradually decrease the maximum amplitude of movement by the controllable actuator over a period of time in a step 352. The period of time may be a predetermined period of time. Alternatively, the rate of decreasing the maximum amplitude of movement may be predetermined or follow a predetermined pattern. In one embodiment, in step 352, the maximum amplitude of movement is gradually reduced to zero.

[0133] This approach helps to gradually reduce the perceived amplitude of the tactile breathing guidance by the individual, reducing sudden changes and decreasing a likelihood of waking the individual.

[0134] In some examples, there is an additional force checking step 353 between steps 351 and 352, which checks the measure of force in the sensor signal. Responsive to this measure of force being larger than the predetermined force threshold, the method moves to step 360 (i.e., step 352 is bypassed). Otherwise, the method moves to step 352. This approach facilitates immediate stopping of the breathing guidance if the individual is not holding the device tightly enough to feel or notice a change in the breathing guidance, thereby saving energy.

[0135] Steps 313, 332, 352 and 390 provide example approaches for steps that are performed using the measure of force carried by the sensor signal.

[0136] In the above-described example, the elapsed time (as indicated by the value of the timer) is sequentially compared to each predetermined time threshold (starting with the smallest) to identify in which time range it falls. The skilled person would be readily capable of modifying this method to make use of other approaches for determining in which time range an elapsed time fall, e.g., comparing to the thresholds in a different order (e.g., starting with the largest) or the like.

[0137] The predetermined force threshold may represent an expected level of force to be applied by an individual when hugging or squeezing the below, e.g., a minimum level of force to be applied that results in the individual being able to perceive the movement of the controllable actuator.

[0138] The predetermined force threshold preferably represents a measure of force that is greater than the value of a measure of force applied when the individual touches (but has not attempted to deform) the tactile breathing guidance device. Thus, the force threshold may be greater than a touch threshold that indicates the individual has touched or begun to touch the tactile breathing control device.

[0139] All thresholds (or other parameters) mentioned above can be defined by user via a user input interface on the device or in communication with the control system. In some examples, each threshold may have a default value at the point of manufacture.

[0140] In some examples, the force threshold can be set, for instance, by a set-up process (e.g., that makes use of a wizard) in which the individual hugs or squeezes the device with a desired or typical level of force. The measure of force carried by the sensor signal in this scenario may be recorded and used for the force threshold.

[0141] In alternative examples, the force threshold may be independently set or defined, e.g., by a clinician or family member.

[0142] The skilled person would be readily capable of developing a control system for carrying out any herein described method. Thus, each step of the flow chart may represent a different action performed by a control system and may be performed by a respective module of the control system.

[0143] Embodiments may therefore make use of a control system. The control system can be implemented in numerous ways, with software and/or hardware, to perform the various functions required. A processor is one example of a control system which employs one or more microprocessors that may be programmed using software (e.g., microcode) to perform the required functions. A control system may however be implemented with or without employing a processor, and also may be implemented as a combination of dedicated hardware to perform some functions and a processor (e.g., one or more programmed microprocessors and associated circuitry) to perform other functions.

[0144] Examples of control system components that may be employed in various embodiments of the present disclosure include, but are not limited to, conventional microprocessors, application specific integrated circuits (ASICs), and field-programmable gate arrays (FPGAs).

[0145] In various implementations, a processor or control system may be associated with one or more storage media such as volatile and non-volatile computer memory such as RAM, PROM, EPROM, and EEPROM. The storage media may be encoded with one or more programs that, when executed on one or more processors and/or control systems, perform the required functions. Various storage media may be fixed within a processor or control system or may be transportable, such that the one or more programs stored thereon can be loaded into a processor or control system.

[0146] As previously explained, embodiments provide a control system that controls the operation of a tactile breathing guidance device responsive to a sensor signal generated by a force sensing system.

[0147] Accordingly, there is also provided a feedback system comprising the control system and the force sensing system. There is also provided a tactile breathing guidance system comprising the feedback system and the tactile breathing guidance device.

[0148] The force sensing system may comprise one or more flex sensors carried by the tactile breathing guidance device. A flex sensor is a sensor that measures the amount of deflection or bending applied by an individual to the sensor (both of which act as a measure of the force applied by the individual to the tactile breathing guidance device). An alternative label for a flex sensor is a bend sensor. Suitable examples are well known in the art, and include conductive ink based flex sensors, fiber optic flex sensors, capacitor flex sensors and/or Velostat ® based flex sensors.

[0149] Usually, an electrical property of the flex sensor (e.g., the impedance, resistance and/or capacitance) varies for different levels of bending or flexing thereof surface. Since this electrical property is related to the amount of bend, such sensors can also be used as goniometers, and are often called flexible potentiometers.

[0150] By positioning the force sensing system such that it is carried by the tactile breathing guidance device, it is able to measure the force applied by the individual to the force sensing systems (e.g., to the flex sensor(s)).

[0151] If used, each flex sensor may be stuck to the interior or exterior surface of the outermost layer of the tactile breathing guidance. This increases the sensitivity of the force sensing system to a force applied by the individual.

[0152] Of course, the skilled person would appreciate that the force sensing system may comprise other force sensors instead of or in additional to the flex sensor(s). The use of flex sensor(s) is preferred, as they are less perceptible to an individual applying force to the tactile breathing guidance device (as they flex and bend with a flexing of the device). Examples of suitable alternative force sensors include strain sensors, weight sensors and so on.

[0153] In examples where the force sensing system comprises more than one force sensor, the sensing signal may carry a force measurement measured by each force sensor (i.e., multiple force measurements). The measure of force used for controlling the operation of the tactile breathing guidance device may be produced by combining these force measurements, e.g., summing or averaging the force measurements. In some examples, only the force measurements that are greater than a predetermined minimum force value contribute to the measure of force.

[0154] Fig. 4 illustrates a portion of a tactile breathing guidance system 400 according to an embodiment. For the sake of illustrative clarity, any control logic or components (including the control system) has been omitted from the illustration of Fig. 4).

[0155] The tactile breathing guidance system 400 comprises a tactile breathing guidance device 490 (comprising a controllable actuator 491, which is here a controllably inflatable airbag) and a force sensing system 420.

[0156] The force sensing system 420 comprises at least two force sensors 421, 422 positioned on opposite sides of the tactile breathing guidance device 490, e.g., either side of the controllable actuator 491. This covers a greater breadth of measurement range.

[0157] This can also aid in sensing a hugging of the device 400 by the individual, as for a normal hugging posture, the device would have one side touching the individual's chest and its opposite side touching the user's arm. It would therefore be advantageous to position sensors capable of detecting a force applied from both of these directions.

[0158] In some advantageous embodiments, the force sensing system 420 is positioned to avoid or be distanced from the controllable actuator 491 and/or an area that is moved by the controllable actuator. In the context of the illustrated tactile breathing guidance system, this means that the force sensing system is distanced from the airbag. It has been recognized that the movement of the controllable actuator can affect the performance, accuracy and/or operation of the force sensing system 420 (e.g., by erroneously detecting actuator-resultant movement as individual force application).

[0159] Thus, in preferred examples, the force sensing system (i.e., the force sensor(s) thereof) is positioned such that movement resulting from the operation of the controllable actuator has no or negligible impact on the measure of force produced by the force sensing system. The skilled person would appreciate that the precise location or positioning of such a force sensing system will depend upon the specific embodiment implementations, as different devices will have different dimensions and the like.

[0160] It will be understood that disclosed methods are preferably computer-implemented methods. As such, there is also proposed the concept of a computer program comprising code means for implementing any described method when said program is run on a control/processing system, such as a computer. Thus, different portions, lines or blocks of code of a computer program according to an embodiment may be executed by a control/processing system or computer to perform any herein described method.

[0161] There is also proposed a non-transitory storage medium that stores or carries a computer program or computer code that, when executed by a control/processing system, causes the control/processing system to carry out any herein described method.

[0162] In some alternative implementations, the functions noted in the block diagram(s) or flow chart(s) may occur out of the order noted in the Figs. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved.

[0163] Variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. If a computer program is discussed above, it may be stored/distributed on a suitable medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems. If the term "adapted to" is used in the claims or description, it is noted the term "adapted to" is intended to be equivalent to the term "configured to". If the term "arrangement" is used in the claims or description, it is noted the term "arrangement" is intended to be equivalent to the term "system", and vice versa. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A control system (110) for controlling the operation of a tactile breathing guidance device (190, 490) configured to provide tactile guidance of breathing for an individual, the control system comprising:

an input interface (111) configured to receive a sensor signal (Ss) that carries a measure of a force (F) applied by the individual to the tactile breathing guidance device;
an output interface (113) for communicating with the tactile breathing guidance device; and
a data processor (112) communicatively coupled to the input interface and configured to start (319) a timer responsive to the presence of an indicator that the force (F) applied by the individual to the tactile breathing guidance device is greater than a predetermined force threshold (F_T) and control (320), via the output interface, the operation of the tactile breathing guidance device responsive to the sensor signal and the value of the timer.

2. The control system of claim 1, wherein the data processor (112) is configured to control the tactile breathing guidance device to initiate (311) tactile guidance of breathing responsive to the presence of the indicator that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold.

3. The control system of any of claims 1 to 2, wherein the data processor is configured to:
responsive (331, 332) to the value of the timer indicating that a time since starting the timer falls within a first time range (0 - Ts) and the measure of force carried by the sensor signal indicating that the force applied by the individual to the tactile breathing guid-

ance device is lower than the predetermined force threshold, control the tactile breathing guidance device to provide (333) one or more user-perceptible feedback alerts.

4. The control system of claim 3, wherein the data processor is configured to control the tactile breathing guidance device to provide the one or more user-perceptible feedback alerts by:
controlling the tactile breathing guidance device to iteratively provide a user-perceptible feedback alert only whilst the value of the timer indicating that a time since starting the timer falls within the first time range and the measure of force carried by the sensor signal indicating that the force applied by the individual to the tactile breathing guidance device continues to be lower than the predetermined force threshold.

5. The control system of claim 4, wherein the data processor is further configured to:

monitor (334) the number (A) of user-perceptible alerts provided by the tactile breathing guidance device; and
responsive to the number (A) of user-perceptible alerts reaching a predetermined alert threshold (A_T), prevent (335) the generation of any further user-perceptible alerts.

6. The control system of claim 5, wherein the data processor is configured to, responsive to the number (A) of user-perceptible alerts reaching a predetermined alert threshold (A_T) and the force applied by the individual to the tactile breathing guidance device is still lower than the predetermined force threshold:

set the value of the timer to a value that indicates that a time since starting the timer is equal to or greater than an upper bound of the first time range (Ts); and/or
change the upper bound of the first time range to be equal to the time elapsed since starting the timer.

7. The control system of any of claims 3 to 6, wherein

the tactile breathing guidance device (190, 490) comprises a controllable actuator (191, 491) for providing the tactile guidance of breathing for an individual; and
the data processor is configured to, responsive to the value of the timer indicating that a time since starting the timer falls within a first time range (0 - Ts) and the measure of force carried by the sensor signal indicating that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold, adjust (390), via the output interface, a maximum amplitude of movement by the controllable actuator responsive to the measure of force carried by the sensor signal.

8. The control system of any of claims 1 to 7, wherein

the tactile breathing guidance device (190, 490) comprises a controllable actuator (191, 491) for providing the tactile guidance of breathing for an individual; and
the data processor is configured to, responsive (341) to the value of the timer indicating that a time since starting the timer falls within a second time range (Ts - Te), adjust (390), via the output interface, a maximum amplitude of movement by the controllable actuator responsive to the measure of force carried by the sensor signal.

9. The control system of claim 7, when dependent upon any of claims 3 to 6, wherein a lower bound (Ts) of the second time range (Ts - Te) is equal to an upper bound of the first time range (0 - Ts).

10. The control system of any of claims 1 to 8, wherein

the tactile breathing guidance device (190, 490) comprises a controllable actuator (191, 491) for providing the tactile guidance of breathing for an individual; and
the data processor is configured to, responsive (351) to the value of the timer indicating that a time since starting the timer falls within a third time range (Te - Toff) and the measure of force carried by the sensor signal indicating that the force applied by the individual to the tactile breathing guidance device is greater than the predetermined force threshold, reduce (352), via the output interface, a maximum amplitude of movement by the controllable actuator.

11. The control system of claim 9, when dependent upon any of claims 7 or 8, wherein a lower bound (Te) of the third time range (Te - Toff) is equal to an upper bound of the second time range (Ts - Te).

12. A feedback system for controlling the operation of a tactile breathing guidance device for providing tactile guidance of breathing for an individual, the feedback system comprising:

the control system (110) of any of claims 1 to 11; and
a force sensing system (120, 420) communicatively coupled to the input interface of the control system and configured to generate the sensor signal responsive to an amount of force applied by the individual to the tactile breathing guidance

device.

13. The feedback system of claim 12, wherein the force sensing system:

comprises a flex sensor configured to change the sensor signal responsive to an amount of flexing and/or bending of the flex sensor; and/or is configured to change the sensor signal responsive to an amount of hugging or squeezing applied by the individual to the tactile breathing guidance device.

14. A tactile breathing guidance system (100, 200, 400) comprising:

a tactile breathing guidance device (190, 490) configured to provide tactile guidance of breathing to an individual; and
the feedback system of any of claims 12 to 13, wherein:

the force sensing system of the feedback system is carried by the tactile breathing guidance device; and
the tactile breathing guidance device is communicatively coupled to the output interface of the control system of the feedback system.

15. A computer-implemented method (300) for controlling the operation of a tactile breathing guidance device for providing tactile guidance of breathing for an individual, the computer-implemented method comprising:

receiving (312) a sensor signal that carries a measure of a force applied by the individual to the tactile breathing guidance device;
starting (319) a timer responsive to the presence of an indicator that the force applied by the individual to the tactile breathing guidance device is greater than a predetermined force threshold; and
controlling (320) the operation of the tactile breathing guidance device responsive to the sensor signal and the value of the timer.

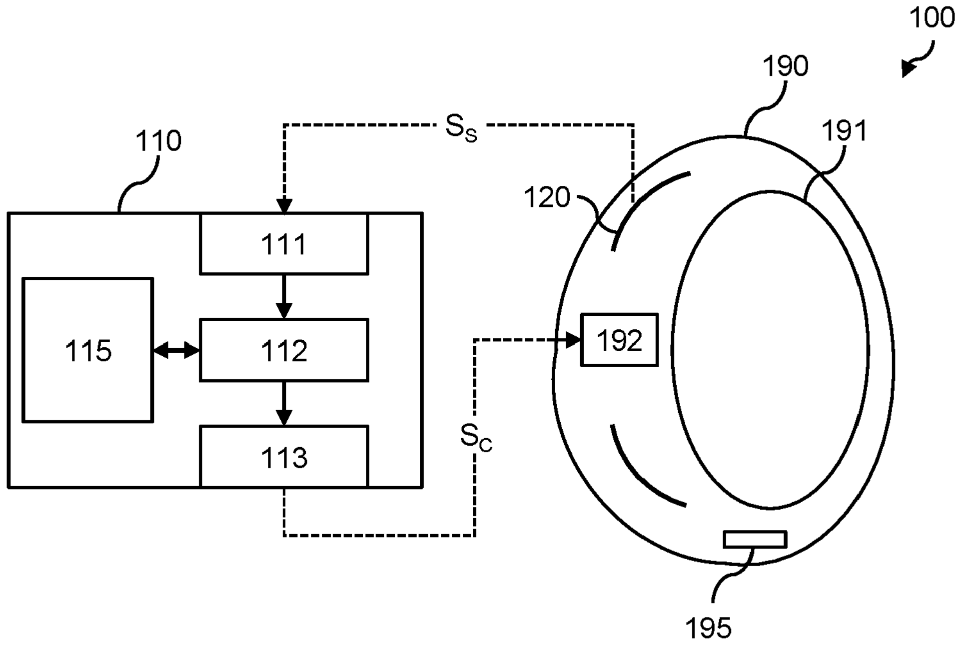

100
190
191
110
120
111
112
113
115
192
195

FIG. 1

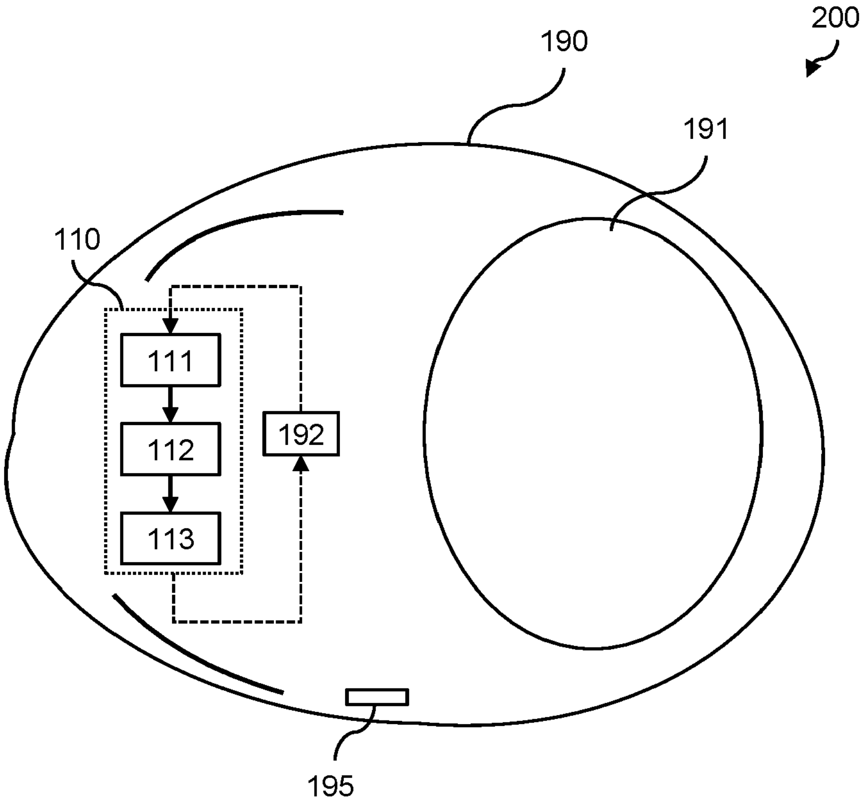
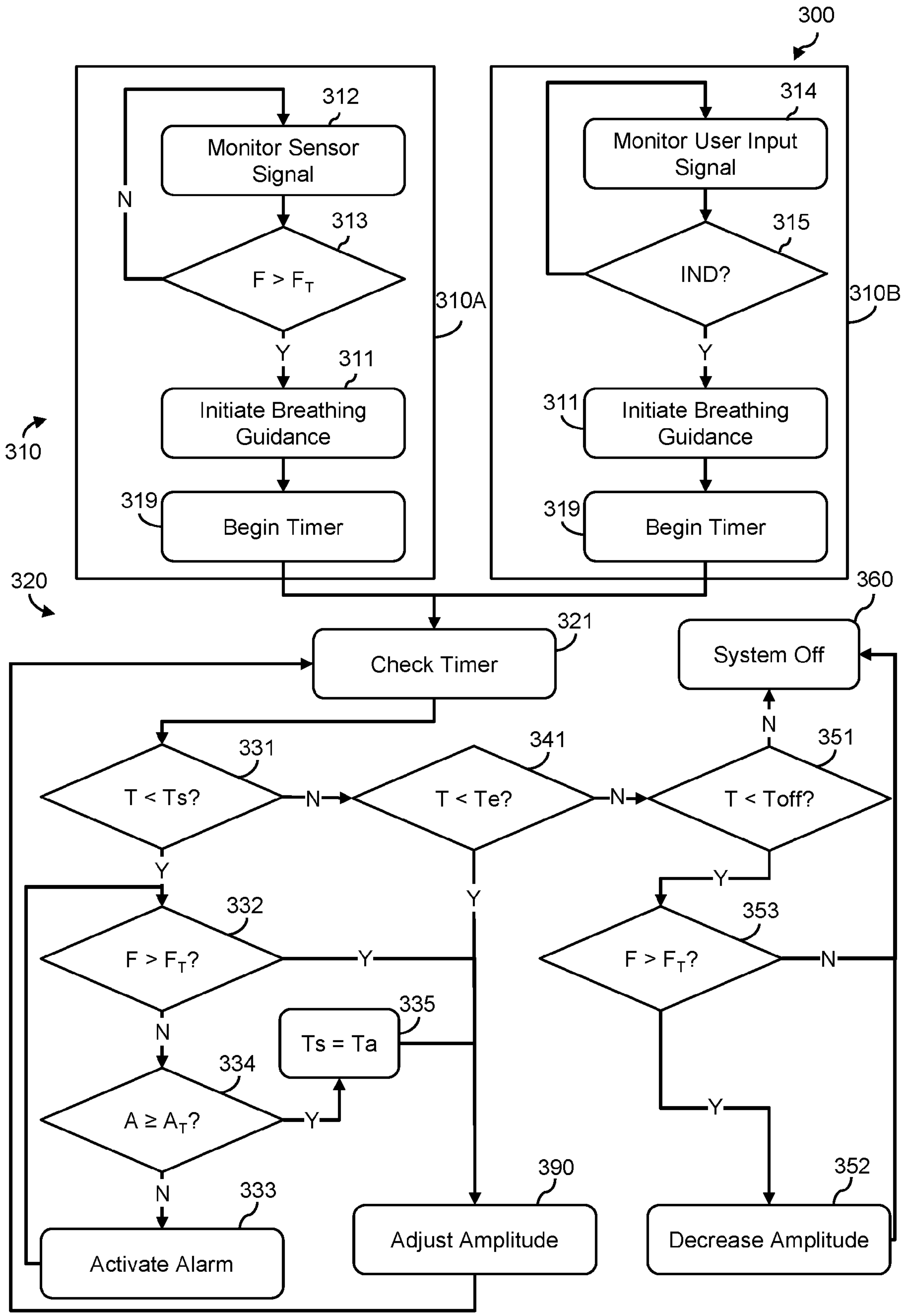

200
190
191
110
111
112
113
192
195

FIG. 2


300
312
Monitor Sensor Signal
N
313
F > F_T
310A
Y
311
Initiate Breathing Guidance
310
319
Begin Timer
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315
IND?
310B
Y
311
Initiate Breathing Guidance
319
Begin Timer
320
321
Check Timer
360
System Off
N
331
T < Ts?
N
341
T < Te?
N
351
T < Toff?
Y
Y
Y
332
F > F_T?
Y
353
F > F_T?
N
N
335
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A ≥ A_T?
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N
333
Activate Alarm
390
Adjust Amplitude
352
Decrease Amplitude

FIG. 3

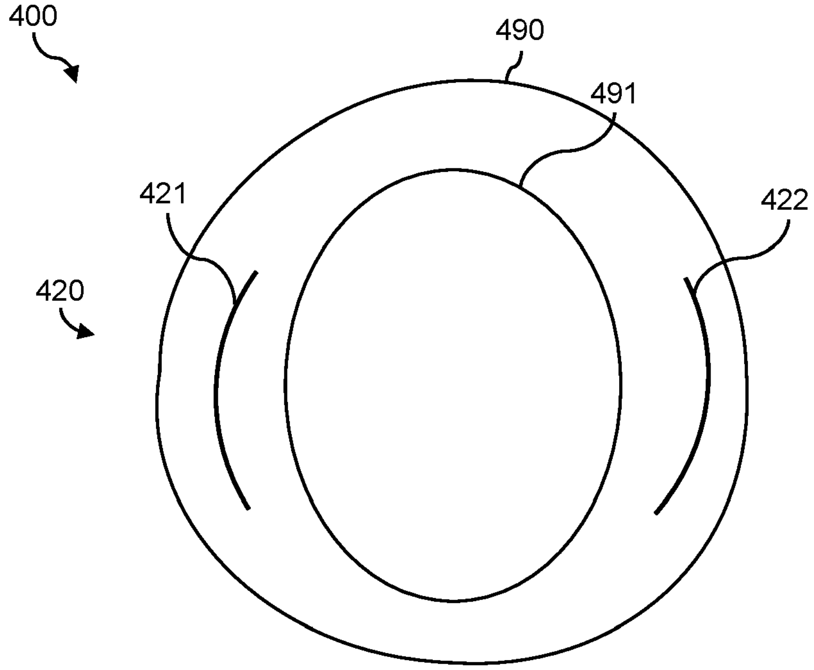

FIG. 4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 15 3178

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2013/310636 A1 (KRANS JAN [NL] ET AL) 21 November 2013 (2013-11-21) * paragraph [0005] - paragraph [0074]; figures *	1-15	INV. A63B23/18
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Place of search	Date of completion of the search	Examiner
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