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United States Patent
Gray , et al.**11,311,210**
April 26, 2022

Posture analysis systems and methods

Abstract

Example posture analysis systems and methods are described. In one implementation, a computing system identifies a deviation of a user's posture from a predetermined posture based on visual data associated with the user. The user is informed of the deviation via a graphical image displayed on a display device. The user is then provided with instructions for correcting the deviation via the graphical image displayed on the display device.

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Family ID: 1000006262684

Appl. No.: 15/650,592

Filed: July 14, 2017

Prior Publication Data**Document Identifier**

US 20180014754 A1

Publication Date

Jan 18, 2018

Related U.S. Patent Documents**Application Number**

62362391

Filing Date

Jul 14, 2016

Patent Number**Issue Date****Current U.S. Class:****1/1****Current CPC Class:**

A61B 5/1116 (20130101); A61B 5/743 (20130101); A61B 5/7455 (20130101); A61B 5/1036 (20130101); A61B 2562/0219 (20130101); A61B 5/486 (20130101)

Current International Class:

A61B 5/11 (20060101); A61B 5/00 (20060101); A61B 5/103 (20060101)

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Parent Case Text

RELATED APPLICATION

This application claims the priority benefit of U.S. Provisional Application Ser. No. 62/362,391, entitled "Tracking and Correcting Posture of a User," filed on Jul. 14, 2016, the disclosure of which is hereby incorporated by reference herein in its entirety.

Claims

The invention claimed is:

1. A method comprising: identifying, by a computing system, a deviation of a user current posture from a user reference posture based on visual data associated with the user, wherein the identifying is performed in three dimensions, the identifying including: establishing the user reference posture for the user, including: performing a facial detection on reference visual data; processing reference motion visual data associated with the user's left shoulder and the user's right shoulder responsive to any of: the user wiggling the user's left shoulder and the user's right shoulder; the user swaying from side to side; and the user separately stroking their left shoulder and their right shoulder; determining the user current posture, the determining including: performing another facial detection on current visual data; and determining a position of the user's left shoulder and the user's right shoulder from the current visual data; computing the deviation as a difference between the user reference posture and the user current posture; informing the user, via a graphical image displayed on a display device, of the deviation; and providing instructions, via the graphical image displayed on the display device, for correcting the deviation.
2. The method of claim 1, wherein the user is informed of the deviation in substantially real time.
3. The method of claim 1, wherein informing the user of the deviation includes displaying an image depicting the predetermined posture and simultaneously displaying a current representation of the user's posture.
4. The method of claim 3, wherein the displayed image is updated in substantially real time.
5. The method of claim 1, wherein the graphical image is displayed responsive to the deviation being above a predetermined threshold.

6. The method of claim 1, further comprising: determining, based on visual data associated with the user, whether the user has corrected their posture; and removing the graphical image responsive to determining that the user has corrected their posture.

7. The method of claim 1, wherein the instructions include at least one of a textual message, a graphical symbol, audio feedback, or shading a portion of the graphical image based on the deviation.

8. The method of claim 1, further comprising color-coding the instructions based on a time duration associated with the deviation.

9. The method of claim 1, further comprising providing a congratulatory message to the user when the deviation has been corrected.

Description

TECHNICAL FIELD

The present disclosure relates to systems and methods that analyze and track a user's posture.

BACKGROUND

In many situations, people spend significant amounts of time in front of desktop computers, laptop computers, display screens, or sitting in particular chairs or other seating devices. Long hours in these types of situations may be associated with unhealthy posture habits, which the person may be unaware of. In contrast, having a good posture may allow a person to avoid certain problems associated with sitting, standing, or other positions with an incorrect posture.

Incorrect posture can cause problems a person's spine, back or neck which may result in pain or other problems. In some situations, health may be improved if proper posture is attained. There exists a need for a system that helps a user maintain proper posture in a variety of situations.

BRIEF DESCRIPTION OF THE DRAWINGS

Non-limiting and non-exhaustive embodiments of the present disclosure are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various figures unless otherwise specified.

FIG. 1A is a block diagram depicting an embodiment of a posture analysis system.

FIG. 1B is a block diagram depicting an embodiment of a graphical image as displayed by a posture analysis system.

FIG. 2 is a block diagram depicting an embodiment of a computing system capable of implementing a posture analysis system.

FIG. 3 is a block diagram depicting an embodiment of an image analysis module.

FIG. 4 is a block diagram depicting an embodiment of a user feedback module.

FIGS. 5A-5E represent a flow diagram depicting an embodiment of a method to track and correct a user's posture in substantially real time.

FIG. 6 is a schematic diagram depicting an embodiment of a posture analysis system interface that shows a registration of a predetermined posture.

FIG. 7 is a schematic diagram depicting an embodiment of an interactive posture correction sequence.

FIG. 8 is a schematic diagram depicting another embodiment of an interactive posture correction sequence.

FIG. 9 is a schematic diagram depicting an embodiment of a sequence of frames to determine a user's posture.

FIG. 10 is a schematic diagram depicting an embodiment of a workflow that illustrates the operation of a posture analysis system.

FIGS. 11A and B represent a flow diagram depicting an embodiment of a method to track and correct a user's posture based on image recognition.

FIGS. 12A and B represent a flow diagram depicting an embodiment of a method to characterize a user's posture.

FIG. 13 is a schematic diagram illustrating an embodiment of an application of a posture tracking system.

FIG. 14 is a schematic diagram illustrating an embodiment of another application of a posture tracking system.

DETAILED DESCRIPTION

In the following description, reference is made to the accompanying drawings that form a part thereof, and in which is shown by way of illustration specific exemplary embodiments in which the disclosure may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the concepts disclosed herein, and it is to be understood that modifications to the various disclosed embodiments may be made, and other embodiments may be utilized, without departing from the scope of the present disclosure. The following detailed description is, therefore, not to be taken in a limiting sense.

Reference throughout this specification to "one embodiment," "an embodiment," "one example," or "an example" means that a particular feature, structure, or characteristic described in connection with the embodiment or example is included in at least one embodiment of the present disclosure. Thus, appearances of the phrases "in one embodiment," "in an embodiment," "one example," or "an example" in various places throughout this specification are not necessarily all referring to the same embodiment or example. Furthermore, the particular features, structures, databases, or characteristics may be combined in any suitable combinations and/or sub-combinations in one or more embodiments or examples. In addition, it should be appreciated that the figures provided herewith are for explanation purposes to persons ordinarily skilled in the art and that the drawings are not necessarily drawn to scale.

Embodiments in accordance with the present disclosure may be embodied as an apparatus, method, or computer program product. Accordingly, the present disclosure may take the form of an entirely hardware-comprised embodiment, an entirely software-comprised embodiment (including firmware, resident software, micro-code, etc.), or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module," or "system." Furthermore, embodiments of the present disclosure may take the form of a computer program product embodied in any tangible medium of expression having computer-usable program code embodied in the medium.

Any combination of one or more computer-usable or computer-readable media may be utilized. For example, a computer-readable medium may include one or more of a portable computer diskette, a hard disk, a random access memory (RAM) device, a read-only memory (ROM) device, an erasable programmable read-only memory (EPROM or Flash memory) device, a portable compact disc read-only memory (CDROM), an optical storage device, and a magnetic storage device. Computer program code for carrying out operations of the present disclosure may be written in any combination of one or more programming languages. Such code may be compiled from source code to computer-readable assembly language or machine code suitable for the device or computer on which the code will be executed.

Embodiments may also be implemented in cloud computing environments. In this description and the following claims, "cloud computing" may be defined as a model for enabling ubiquitous, convenient, on-

embodiments, image processing techniques such as computer vision, facial detection and facial recognition may be used in conjunction with machine learning algorithms to analyze and appropriately characterize the visual data received by computing system 102. In some embodiments, computer vision software libraries, such as OpenCV, may be used to implement certain functions of posture analysis system 100, such as analysis of visual data.

In some embodiments, a second step associated with the operation of posture analysis system 100 is a tracking step where a current posture of user 104 is tracked by computing system 102 in substantially real time based on visual data received from imaging device 106. In some embodiments, the term "substantially real time" includes operation with a small time delay such as a few seconds or a fraction of a second. In other embodiments, substantially real time may include operation with a longer time delay up to several minutes. In particular embodiments, a temporal history associated with the tracking of the posture of user 104 may be stored and presented to the user at a later time (for example, on display device 108 or via email).

In some embodiments, the current posture of user 104 is tracked relative to the predetermined posture. In some situations, if the tracked current posture of user 104 deviates from the predetermined posture by more than a certain threshold, computing system 102 may inform user 104 about the deviation via a graphical image 110 displayed on display device 108. In some embodiments, user 104 may be informed about the deviation via graphical image 110 in substantially real time. In particular embodiments, graphical image 110 may simultaneously include an image depicting the predetermined posture, an image depicting the current posture of user 104, and information that may allow user 104 to substantially eliminate the deviation and return to the predetermined posture. In some embodiments, information presented in graphical image 110 may be any combination of graphical symbols, textual information and a video rendering of user 104. If user 104 follows the presented information to eliminate the deviation and assumes the predetermined posture again (i.e., if user 104 corrects their posture), computing system 102 may detect that user 104 has assumed the predetermined posture based on the visual data, and may then remove graphical image 110 from display device 108. Details of the initialization and tracking steps are discussed in greater detail herein.

In some embodiments, computing system 102 may associate the current posture of user 104 with a specific task being performed by user 104. In particular embodiments, computing system 102 may associate a deviation of the posture of user 104 from the predetermined posture with a specific task being performed by user 104. In some embodiments, the task being performed by user 104 is an activity being performed by user 104. Examples of the task being performed by the user include using an application executing on computing system 102, reading a book, writing, riding in a vehicle, performing surgery in an operating room, practicing yoga, or any other kind of activity. Posture analysis system 100 may be used in a variety of situations such as operating rooms, airplanes (to ensure a passenger assumes a healthy posture), cars, and so on.

FIG. 1B is a block diagram depicting an embodiment of a graphical image 110 as displayed by a posture analysis system 100. In some embodiments, graphical image 110 may include a line drawing of a predetermined posture 112, and a graphic element 114 corresponding to the current posture of user 104. In some embodiments, graphic element 114 may be an ellipse that corresponds to a position of the face of user 104 in a frame associated with the visual data as determined by facial detection algorithms running on computing system 102. In some embodiments, graphic element 114 may be a polygon. In particular embodiments, graphic element 114 may be any combination of a cartoon character, a photographic depiction of a head, shoulders and a body, a three-dimensional mesh rendering of a head, shoulders and a body, a cut-out rendition of the face of user 104 on a comical background, an image of another person, an animal (e.g., a bunny), and the like. In some embodiments, graphical image 110 may be generated by computing system 102 and rendered on display device 108 in substantially real time.

The position of graphic element 114 in graphical image 110 correlates with a spatial position of the face of user 104 which, in turn, can be mapped to the current posture associated with user 104. In some embodiments, graphical image 110 may also include a text box 116 that provides posture correction information to user 104. If user 104 follows the posture correction information, user 104 can be guided back to assume the predetermined posture. FIG. 1B depicts text box 116 as informing user 104 to move right and back (i.e., away from display device 108) to achieve the predetermined posture. Further details of the posture correction step that involve substantially eliminating a deviation associated with a user's current posture from the predetermined posture are provided herein.

performed in the user's presence. In other embodiments, this characterization may be performed in the user's absence. Background initialization manager 302 may include one or more visual reference points from the background as a part of any background initialization data that may be used for further processing. In some embodiments, characterizing the background associated with the user is performed by asking the user to sway from side to side, capturing the swaying motion of the user, and then using, for example, optical flow algorithms to determine any portions of the associated captured visual data that are non-stationary with respect to time. Non-stationary areas of the visual data are associated with the user swaying motion, versus the background not moving and associated with temporally static visual data. The temporally static visual data is used to characterize or initialize the background. In some embodiments, the user may be asked to sway to their left, sway to their right, and then return back to their center to complete the background characterization (initialization) process.

In some embodiments, image analysis module 118 may include a background tracking manager 304 that is configured to perform dynamic tracking on the background associated with the user in order to compensate for any dynamic components that may affect posture tracking of the user. For example, in the event that facial detection algorithms are included in the posture tracking process implemented by computing system 102, there may be other people with faces in the background. In some embodiments, a person may be looking over the shoulder of the user, for example, in response to the user wanting to share some information with the person. In such cases, the image recognition algorithm may recognize more than one face in the visual data and this might lead to errors in the posture tracking process. Background tracking manager 304 is configured to account for such errors and to prevent them from occurring. For example, a face in the background will be at a greater distance from imaging device 106 as compared to the face of user 104, as a result of which the latter will be recognized as a larger ellipse or blob by a facial detection algorithm as compared to the former. Background tracking manager is configured to track the largest ellipse or blob in a frame associated with the visual data as that is most likely the user's face while eliminating any other potentially distracting elements.

In some embodiments, background tracking manager 304 may be configured to compensate for any inadvertent movement in imaging device 106 relative to the position of user 104. For example, if user 104 is using a laptop and changes the tilt or orientation of the screen, the background data associated with user 104 may change. Similarly, the background data associated with user 104 may change if user 104 changes a position of the laptop (e.g., user 104 rotates the laptop, or moves the laptop towards or away from themselves). Background tracking manager 304 may be configured to account for such changes in the background by storing any key visual characteristics of the background and subsequently compensating accordingly. In some embodiments, after an initialization of the system is completed, user 104 is not required to re-initialize a predetermined posture.

Image analysis module 118 may also include a user initialization module 306 that is configured to initialize the system and store a predetermined posture using techniques described herein. In some embodiments, image analysis module 118 may include a posture detection manager 308 that may use image processing algorithms such as facial recognition or face detection to detect the current posture of user 104. In particular embodiments, image analysis module 118 may include a posture tracking manager 310 that is configured to track the current posture of user 104 in real time or substantially real time relative to a predetermined posture. In some embodiments, posture tracking manager 310 may use image processing algorithms such as facial recognition or face detection to track the current posture of user 104.

In some embodiments, image analysis module 118 may include a predetermined posture generator 312 that is configured to retrieve stored data associated with the predetermined posture and generate a rendition of the predetermined posture to be compared with the current posture of user 104. In some embodiments, image analysis module 118 may include a posture comparator 314 that compares the predetermined posture with the current posture of user 104 to compute any deviation in the current posture of user 104 from the predetermined posture. In some embodiments, a deviation in the current posture of user 104 from the predetermined posture is calculated by computing a pixel distance in the visual data between the predetermined posture and the current posture of user 104. In particular embodiments, the pixel distance--up, down, to the left, to the right, or any combination thereof--is a measure of the physical distance or physical deviation of the current posture of user 104 from the predetermined posture. In some embodiments, a percentage difference (increase or decrease) is used to determine any deviation in the current posture of user 104 from the predetermined posture in a direction towards or away from imaging device 106 respectively. If

continued description provided subsequently.

FIG. 5C is a continued description of the method 500. While steps 506 through 522 described the generation of the predetermined posture (that can also be referred to as system calibration), subsequent steps describe the operation of the system with respect to posture monitoring and tracking for a given user associated with a predetermined posture.

Starting at A, the method continues to 524, where the computing system receives current visual data associated with the user. "Current visual data" is used to refer to visual data associated with user posture monitoring and tracking. In some embodiments, the current visual data may be received from imaging device 106. At 526, the method determines the user's current posture along the first axis based on a size of the user's face using facial detection on the current visual data. This process is similar to step 510. At 528, the method determines the user's current posture along the second axis based on a first position of the user's face along the second axis using facial detection on the current visual data. This process is similar to step 512. At 530, the method determines the user's current posture along the third axis based on a second position of the user's face along the third axis using facial detection on the current visual data. This process is similar to step 514. Next, at 532, the method determines a current position of the user's left shoulder using the current visual data. This process is similar to step 516. At 534, the method determines a current position of the user's right shoulder using the current visual data. This process is similar to step 518. The method then proceeds to C, with a continued description provided subsequently.

FIG. 5D is a continued description of the method 500. At 536, the method determines the user's current posture in three dimensions based on the user's current posture along the first axis, the user's current posture along the second axis, the user's current posture along the third axis, the current position of the user's left shoulder and the current position of the user's right shoulder. This process is similar to step 520. Next, at 538, the method tracks the user's current posture in substantially real time. In some embodiments, tracking the user's current posture is performed at a rate that is similar to the frame rate of imaging device 106, for example, 30 frames per second. Other embodiments may implement faster or slower tracking rates depending on the specific system or user requirements or available system resources. For example, frame rates may range from 5 frames per second to 2000 frames per second. At 540, the method associates the user's current posture with a specific task being performed by the user (e.g., a task being performed on the computing system). This association of the user's current posture with a particular task may allow posture analysis system 100 to potentially identify bad posture habits associated with performing the particular task. For example, a user may slouch while using a word processor, crane their neck while reading an email, or shrug their shoulders when watching a video. All these associations of bad posture habits can be associated with a specific task being performed by the user and then provided to the user at a later time to allow them to take corrective steps for assuming a healthy posture.

At 542, the method compares the user's current posture with the predetermined posture. At 544, the method determines whether the user's current posture has deviated from the predetermined posture. In some embodiments, steps 542 and 544 may be accomplished by posture comparator 314. If the user's posture has not deviated from the predetermined posture the method returns to A. If the user's posture has deviated from the predetermined posture the method continues to D, with a continued description provided subsequently.

FIG. 5E is a continued description the method 500. At 546, the method associates the deviation with the specific task being performed by the user. While step 540 associates the user's current posture with a specific task being performed by the user on the computing system, step 546 associates the deviation associated with the user's current posture from the predetermined posture with the specific task being performed by the user. This allows posture analysis system 100 to characterize bad posture habits associated with a user in relation to a specific task being performed by the user. Next, at 548, the method determines whether the deviation is greater than a predetermined threshold. In some embodiments, each of the first axis, the second axis, and the third axis is monitored to determine a deviation in the user's current posture from the predetermined posture. A deviation of the user's current posture from the predetermined posture along one or more axis by over a threshold associated with that axis is sufficient for method 500 to trigger an alert or suggestion to the user. In one example, the thresholds associated with the axes are: Approximately 32 pixels along the second axis in either direction, with the second axis being substantially parallel to a horizon associated with the user. Approximately 18 pixels along the third axis in either direction, with the third axis being substantially orthogonal to the second axis. An approximately 10% to 30% deviation in either direction in the size (length,

displayed on display device 108 using their mouse or use a predetermined or pre-established gesture that may be captured by imaging device 106 and recognized by a computer vision system to confirm that they have assumed the predetermined posture. In response to the confirmation, computing system 102 receives visual data, processes the visual data to extract the predetermined posture, and stores the predetermined posture. In some embodiments, the user may be given a time frame (e.g., 5 seconds or 10 seconds) to assume and maintain the predetermined posture. During this time frame, the computing system receives visual data, processes the visual data to extract the predetermined posture, and stores the predetermined posture.

In some embodiments, computing system 102 may render the predetermined posture as a line drawing 604 on graphical image 602, along with an ellipse 606 that provides a location of the user's face, where ellipse 606 is substantially congruent to and substantially identically located with the face portion of line drawing 604. In some embodiments, ellipse 606 may be replaced by other graphic symbols that may be user selectable, such as cartoon characters, caricatures, renditions of animals, flowers, other kinds of avatars, and the like. In some embodiments, upon successful registration of the predetermined posture, computing system 102 may present a text message 608 to the user confirming that the posture has been registered. For example, as depicted in FIG. 6, text message 608 may read "Posture Registered." The posture analysis system 100 is now configured to begin tracking the user's posture in substantially real time and informing the user of any deviations from the predetermined posture in substantially real time.

FIG. 7 is a schematic diagram depicting an embodiment of an interactive posture correction sequence 700. In some embodiments, a user's current posture may deviate from the predetermined posture. If the computing system determines that this deviation is greater than a predetermined threshold, computing system 102 may alert user 104 by presenting relevant information on a graphical image 702 that includes a line rendition 714 of the predetermined posture. In some embodiments, graphical image 702 may also depict an ellipse 712 corresponding to a three-dimensional position of the user's face relative to the reference posture as represented by line rendition 714. In this case, the deviation of the user's current posture from the predetermined posture is shown to be to the left of line rendition 714. Graphical image 702 may also include textual information such as a text message 710 that prompts the user to shift their posture in a particular direction to reduce or eliminate the deviation. For example, FIG. 7 shows text message 710 displaying the prompt "shift to your right," to allow the user to compensate for the deviation to the left. In addition to text message 710, audio feedback via encoded audio signals or explicit voice recordings may be provided to the user.

FIG. 7 depicts a sequence of events that occurs as displayed to a user, starting with graphical image 702, as the user corrects their posture. In response to the prompt on text message 710, as the user starts to shift to their right, correction sequence 700 may replace graphical image 702 by a graphical image 704 that includes line rendition 714. As the user responds to text message 710 and moves to their right, the rendition of the user's face also moves to the right, as depicted by ellipse 712. In graphical image 704, ellipse 712 is shifted to the right as compared to the position of ellipse 712 in graphical image 702, corresponding to the user's response to the prompt on text message 710. Since there still is a deviation in the user's posture compared to the predetermined posture text message 710 in graphical image 704 still includes text message 710 "shift to your right." In addition to text message 710, audio feedback via encoded audio signals or explicit voice recordings may be provided to the user.

As the user moves further to their right in response to the prompt on text message 710, correction sequence 700 replaces graphical image 704 by a graphical image 706 that includes line rendition 714, as in graphical image 702 and graphical image 704. As the user responds to text message 710 and moves to their right, the rendition of the user's face also moves to the right, as depicted by ellipse 712. In graphical image 706, ellipse 712 is shifted to the right as compared to the position of ellipse 712 in graphical image 704, corresponding to the user's response to the prompt on text message 710. While the user is closer to the predetermined posture in graphical image 706 as compared to graphical image 704, there still is a deviation in the user's posture compared to the predetermined posture; hence text message 710 in graphical image 706 still reads "shift to your right." In addition to text message 710, audio feedback via encoded audio signals or explicit voice recordings may be provided to the user.

Once the user assumes the predetermined posture as shown by a graphical image 708, a rendition of the user's face via ellipse 712 now coincides with the representation of the user's face on line rendition 714 that depicts the predetermined posture, as depicted on graphical image 708. Since the user has now assumed the

predetermined posture and corrected for the deviation, text message 710 in graphical image 708 may now depict a check mark 716 that provides a confirmation to the user that they have assumed the predetermined posture. In some embodiments, check mark 716 may be replaced with a congratulatory message or some other congratulatory graphic that may be displayed while posture analysis system may also provide audio feedback to the user via encoded audio signals or explicit voice recordings.

In some embodiments, posture analysis system 100 may remove the graphical image, such as graphical image 708, from display device 108 after a certain time interval once the user assumes and maintains the predetermined posture. In some embodiments, processing system 102 may process visual data at a lower frame rate once the user has assumed the predetermined posture with graphical image 708 removed from display device 108. This is done to reduce any computing resource utilization by posture analysis system 100 on computing system 102 when the user maintains the predetermined posture. When the user deviates from the predetermined posture and needs interactive feedback, processing system 102 may process visual data at a higher frame rate to provide substantially real time updates to the user via a graphical image such as graphical image 702.

FIG. 8 is a schematic diagram depicting another embodiment of an interactive posture correction sequence 800. In some embodiments, a user's current posture may deviate from the predetermined posture. If the computing system determines that this deviation is greater than a predetermined threshold, computing system 102 may alert user 104 by presenting relevant information on a graphical image 802 that includes a line rendition 814 of the predetermined posture. In some embodiments, graphical image 802 may also depict an ellipse 812 corresponding to a three-dimensional position of the user's face relative to the reference posture. In this case, the deviation in the user's current posture from the predetermined posture is in a direction towards imaging device 106 (i.e., the user's current position is too close to imaging device 106 relative to the predetermined posture), resulting in larger facial dimensions as determined by a facial detection algorithm running on computing system 102. Graphical image 802 may also include textual information such as a text message 810 that prompts the user to shift their posture in a particular direction to reduce or eliminate the deviation. For example, FIG. 8 shows text message 810 displaying the prompt "move backwards." In addition to text message 810, audio feedback via encoded audio signals or explicit voice recordings may be provided to the user.

FIG. 8 depicts a sequence of events that occurs as displayed to a user starting with graphical image 802 as the user corrects their posture. In response to the prompt on text message 810, as the user starts to move backwards, correction sequence 800 may replace graphical image 802 with a graphical image 804 that includes line rendition 814. As the user responds to text message 810 and moves backwards, the size of ellipse 812 in graphical image 814 associated with the rendition of the user's face reduces and begins to approach the size of the face in the predetermined posture as represented by line rendition 814. (The size of the user's face is depicted by ellipse 812.) Since there still is a deviation in the user's posture compared to the predetermined posture, text message 810 in graphical image 804 still reads "move backwards." In addition to text message 810, audio feedback via encoded audio signals or explicit voice recordings may be provided to the user.

As the user continues to move backwards in response to the prompt on text message 810, correction sequence 800 replaces graphical image 804 by a graphical image 806 that includes line rendition 814, as in graphical image 802 and graphical image 804. As the user responds to text message 810 and moves backwards, the rendition of the user's face (i.e., the size of ellipse 812 used to depict the user's face in graphical image 806) also reduces in size. While the user is closer to the predetermined posture, there still is a deviation in the user's posture compared to the predetermined posture; hence text message 810 in graphical image 806 still reads "move backwards." In addition to text message 810, audio feedback via encoded audio signals or explicit voice recordings may be provided to the user.

Once the user assumes the predetermined posture to reach a final state 808, a rendition of the user's face via ellipse 812 now coincides with the representation of the user's face on line rendition 814 that depicts the predetermined posture, as depicted on graphical image 808. Since the user has now assumed the predetermined posture and corrected for the deviation, text message 810 in graphical image 808 may now depict a check mark 816 that provides a confirmation to the user that they have assumed the predetermined posture. In some embodiments, check mark 816 may be replaced with a congratulatory message or some other congratulatory graphic that may be displayed while posture analysis system may also provide audio

feedback to the user via encoded audio signals or explicit voice recordings.

In some embodiments, feedback provided to the user to correct their posture may include shading at least one portion of graphical image 110 based on the deviation of the user's current posture from the predetermined posture. In particular embodiments, the term "shading" is used to signify operations such as reducing the luminosity of at least one portion of graphical image 110, changing the color of at least one portion of graphical image 110, and the like. In some embodiments, the shading may be graduated to transition (or fade) into the remaining portion of graphical image 110 that is not shaded. In other embodiments, there may be a high contrast between a shaded portion and an unshaded portion of graphical image 110. In particular embodiments, the shading may be transparent. In other embodiments, the shading may be opaque. In still other embodiments, the shading may be translucent.

In some embodiments, a portion of graphical image in a direction corresponding to the deviation may be shaded. For example, if the user deviates to their right, a right-hand portion of graphical image 110 may be shaded. If the user deviates above the predetermined posture, a top portion of graphical image 110 may be shaded. Forwards or backwards deviations may be denoted by introducing vignetting (i.e., lightening or darkening a periphery) of graphical display 110. Combinations of deviations along separate axes (e.g., up and left) may be denoted by shading, for example a top left corner (to include a left-hand edge and a top edge) of graphical display 110, and so on.

In some embodiments, the concept of shading may be extended to display device 108, where at least one portion of display device 108 is shaded based on a deviation of the user's current posture from the predetermined posture. The methods and techniques described above for shading graphical display 110 may also be used on display device 108. In a particular embodiment, one or more edges associated with display device 108 may be shaded depending on the direction of the deviation. For example, if the deviation is to the right of the user, a right-hand edge or a right-hand portion of display device 108 may be shaded to alert the user of the deviation and the associated direction. Or, if the deviation is to the left and down, a lower left-hand corner (to include a bottom edge and a left-hand edge) of display device 108 may be shaded.

In some embodiments, posture analysis system 100 may remove the graphical image such as graphical image 110 or graphical image 808 from display device 108 after a certain time interval once the user assumes and maintains the predetermined posture. In some embodiments, processing system 102 may process visual data at a lower frame rate once the user has assumed the predetermined posture with graphical image 110 removed from display device 108. This is done to reduce any computing resource utilization by posture analysis system 100 on computing system 102 when the user maintains the predetermined posture. When the user deviates from the predetermined posture and needs interactive feedback, processing system 102 may process visual data at a higher frame rate to provide substantially real time updates to the user via graphical image 802.

In some embodiments, the user's shoulders will be indicated both with the predetermined posture and the current user posture with a box and a colorful icon which should be in the box, or by using any other graphical, textual or audible feedback method. In some instances, the user's head might move forward but the shoulders stay in place. This motion implies that the user is craning their head forward. Or, the user's shoulders may be moving up left and/or right. This posture suggests that the user may be shrugging. As another example, the user's shoulders may be rendered as falling down left and/or right. This is associated with the possibility of a deflating-kind of posture. In some embodiments, user messages presented in response to, for example, the user shrugging may be similar to "You are shrugging left" or "You are shrugging right," depending on which direction the user is shrugging. The corresponding visual depiction could include a close-up of a shoulder, neck, part of head that shows a shoulder out of place and a downward arrow suggesting that the user lower their shoulder.

FIGS. 7 and 8 characterize the three-dimensional operational ability of posture analysis system 100. The individual scenarios indicated in FIGS. 7 and 8 are example representations provided for purposes of explanation. In some embodiments, a user posture may be a combination of the scenarios depicted in FIGS. 7 and 8, which would constitute a full three-dimensional representation. Being able to dynamically suggest posture corrections allows posture analysis system 100 to detect and suggest corrections for unhealthy postures such as slouching, shrugging, craning of the neck, and so on by a user. Including the position of the user's shoulders provides increased capability to the system in some conditions such as craning of the neck,

while also allowing posture analysis system 100 to characterize the position of the user's head in relation to the user's shoulders. In particular embodiments, the position of the user's face is sufficient to characterize the user's current posture and provide associated posture correction feedback.

In some embodiments, posture analysis system 100 can also provide additional visual cues that help the user correct their posture. For example, suppose the deviation in the current posture of the user from the predetermined posture is to the left. Posture analysis system may shade a portion of the left-hand side of graphic element 114 to provide a visual cue to the user to shift to the right. Sections of graphic element 114 may be shaded in a similar fashion, respectively corresponding to deviations in the user's posture from the predetermined posture.

In some embodiments, posture analysis system 100 can also provide suggestions other than posture corrections. These suggestions may be aimed at, for example, reducing user fatigue. For instance, posture analysis system 100 may detect that a user may have assumed the predetermined posture without moving for a particular period of time. Since assuming a particular posture for long periods of time without moving is also unhealthy, posture analysis system 100 can provide a user with prompts, suggesting that they get up, take a break, shift their position, or stretch.

The system may also include blink detection. A facial detection algorithm may include an ability to detect and monitor a user's eyes. If posture analysis system 100 determines that the user has not blinked for a period of time, posture analysis system 100 can prompt the user accordingly, thus aiming to reduce eye fatigue.

To reduce resource utilization by posture analysis system 100 on computing system 102, posture analysis system 100 may use a relatively high frame rate of 30 frames per second of visual data when a deviation is detected in the user's current posture as compared to the predetermined posture, such as during the time when graphical image 110 is being displayed to the user along with the associated feedback. When the user has assumed the predetermined posture after correcting for the deviation, graphical image 110 may be removed and the processing frame rate may be reduced.

In some embodiments posture analysis system 100 may include a lag of approximately 1/3 seconds, or 320-370 milliseconds to account for a user swaying back and forth about a mean position that is the predetermined posture, a process considered acceptable and encouraged for maintaining healthy posture. Without the built-in lag, posture analysis system 100 may exhibit an overly sensitive response to user inputs. In alternate embodiments, any value may be used as a time lag in posture analysis system 100.

In some embodiments, a user may be able to configure the line representation associated with graphical image 110, and may have access to customized avatars to allow them to customize the graphical image to their taste. In some embodiments, the colors associated with graphical image 110 may be automatically configured by posture analysis system 100 in accordance with importance. For example, an initial deviation in the user's posture may be rendered on graphical image 110 in subtle colors (for example, green). However, these colors may be replaced by stronger, more saturated colors (e.g., red or orange) if the user does not pay attention to the posture correction alerts for a certain period of time. As another example, yellow may be used to denote an initial deviation in the user's posture relative to the predetermined posture, orange may be used for a longer time period associated with the deviation, while an even longer time period associated with the deviation may be rendered in red. Also, blue may be used to alert the user if they are frozen in a particular posture for greater than, for example, 30 seconds. In some embodiments, vibrant primary colors may be used to capture the user's attention from the corner of their eye while they are focused on another task on, for example, display system 108. These colors could be applied to, for example, the text message, the line rendition of the predetermined posture, and the ellipse corresponding to the rendition of the user's face. In some embodiments, the time period associated with changing the colors displayed on graphical image 110 due to lack of user response may range from 2 seconds to 30 minutes. In particular embodiments, the size of graphical image 110 in relation to display system 106 may also be increased in accordance with a user not responding to alerts for a certain time period.

In some embodiments, visual data provided by imaging device 106 may not be of acceptable quality if light levels are low. This limitation may be, for example, due to the small apertures associated with the lens incorporated into imaging device 106. To work around this limitation, a color image from imaging device 106 may be converted into a grayscale image that is processed in a histogram equalization algorithm that

of imaging device 106. In some embodiments, a background initialization step 1006 characterizes a background model 1008 in the absence of the user (i.e., when the user is not in the field of view of imaging device 106). This activity allows posture analysis system 100 to appropriately determine the presence of the user as a foreground element to accomplish posture tracking. In some embodiments, a machine learning classifier may be used to create a background model. In other embodiments, background initialization 1006 may be skipped altogether.

A user initialization step 1010 characterizes a predetermined posture associated with a user. In some embodiments, the user positions themselves in the field of view of imaging device 106 to perform initialization step 1010. In some embodiments, initialization step 1010 includes receiving a frame 1014 containing an image of the user, using image processing techniques (such as convex hull and blob analysis) to generate a frame 1016 containing a convex hull associated with the user's image profile, using face detection and facial detection techniques to confirm a presence of the user's face in a generated frame 1018. Additionally, the system generates a frame 1020 containing an outline of the user's profile, finally generating a frame 1012 that confirms the outline of the user's profile and storing data associated with frame 1012 as the predetermined posture. In some embodiments, the predetermined posture associated with user initialization step 1010 may be determined via professional input such as input from a therapist, ergonomics professional, a coach, in person, or via the internet in a video chat, general information from the Internet, and so on.

A posture tracking step 1022 tracks the user's posture in substantially real time. In some embodiments, the user positions themselves in the field of view of imaging device 106 to perform posture tracking step 1022. In some embodiments, posture tracking step 1022 includes receiving a frame 1026 containing an image of the user, using image processing techniques (such as convex hull and blob analysis) to generate a frame 1028 containing a convex hull associated with the user's image profile. In some embodiments, posture tracking step 1022 uses face detection and facial detection techniques to confirm a presence of the user's face in a generated frame 1030, generating a frame 1030 containing an outline of the user's profile relative to the predetermined posture. Next, posture tracking step 1022 generates a frame 1032 that confirms the outline of the user profile. Finally, posture tracking step 1022 generates a frame 1024 that confirms the outline of the user's profile and current posture relative to the predetermined posture. In some embodiments, posture tracking step 1022 as implemented by posture analysis system 100 may be capable of re-initializing posture tracking of a user even when the user returns after having exited from the field of view of imaging device 106. In some embodiments, posture tracking step 1022 as implemented by posture analysis system 100 can detect a physical movement or other impairment in imaging device 106, and can autonomously recognize the need to redo the background learning and posture calibration steps, without the user needing to take any actions.

In some embodiments, background initialization step 1006, user initialization step 1010, and posture tracking step 1022 may be carried out in any order, not necessarily in the sequence presented in FIG. 10. In some embodiments, posture analysis system 100 may be configured to detect when the user has left the field of view of the camera based on, for example, information stored from background initialization step 1006.

In some embodiments, a user interface presented by posture analysis system 100 may include buttons and a visual display. The visual display may include a live-video display of the scene captured by the camera. If the user is recognized in the scene, a mask is displayed around the user's boundary. The mask is a region of pixels outside the boundary of the user's body as detected by posture analysis system 100, and the region may be blurred such that the background scene appears opaque. In operation, the user's objective is to keep their body within the clear boundary of pixels. Thus, the user may observe a visual image of their current posture in the form of a boundary in which they may position the user's body. When they move out of the boundary, they can be made aware of this as their actual position is shown outside the boundary shown in the image.

The ideal posture can also be indicated by a simple outline or by creating an avatar of the real person inside of the person's outline. The user may then change or otherwise correct their position so that the image of their actual position coincides with the image projected in the visual boundary shown to them. When an optimum position is achieved, the visual representation may indicate that the user is in the proper position, which may change if a user moves. For example, the image may appear bright green when a user is in a preferred position, and may change to red if the user poses outside the boundary of the preferred position. Audible alerts may also be incorporated, alerting the user that their posture is outside the boundaries. The

appearance or audible sound of such an alert may be varied depending on the preferred user experience, avoiding annoying alerts that might distract or distress the user.

In some embodiments, an output step 1034 presents posture tracking results to a user via a display output 1036. In some embodiments, display output 1036 is identical to graphical image 110. In some embodiments, an image of the user and an outline of the predetermined posture may be presented. In other embodiments, the image of the user may be replaced with a graphic element such as an ellipse. Depending on the deviation of the user's current posture from the predetermined posture, display output 1036 may show different colors. For example, if the user has assumed the predetermined posture display output 1036 may use a green color for rendering certain elements. If the user deviates from the predetermined posture, display output 1036 may use other colors such as yellow or red, depending on the severity of the deviation.

Posture analysis system 100 can be used to correct posture at a computer desk or working in proximity to any type of display device. Posture analysis system 100 can also be used to guide users in full body postures and movements, if the visual data from imaging device 106 is interpreted and sent to (3D)-video-glasses, helmet-mounted displays, or a fixed monitor, or if the positioning feedback is verbalized and played as audio feedback to the user. Posture analysis system 100 is also useful in situations such as yoga, physical therapy, exercise, stretching, or any other learning of body movement where the sequence and feedback would be at least similar to the posture feedback discussed herein. Other applications include realizations in airplanes, buses, trains, and cars, where the immediate background is fairly static. In these applications, the background may be less relevant with regards to processing functions, and the focus is primarily on the user in front of imaging device 106.

FIG. 11A represents a flow diagram depicting an embodiment of a method 1100 to track and correct a user's posture based on image recognition. At 1102 the method receives visual data associated with a user's face, shoulders and chest. In some embodiments, the visual data may be received by processing system 102 from imaging device 106. At 1104, the method extracts information about a largest blob in a frame associated with the visual data. In some embodiments, the largest blob is associated with a foreground rendition of the user in the frame, to include the user's head, shoulders and chest. At 1106, the method determines a convex hull associated with the largest blob, where a convex hull is defined as the smallest convex set that contains all the points of the largest blob. Next, at 1108, the method determines whether the convex hull includes the user's face, using techniques such as facial detection. If the convex hull does not include the user's face then the method goes to B and returns back to 1102, where the system reattempts to detect the presence of the user's face in the visual data. On the other hand if, at 1108, the convex hull includes the user's face then the method goes to 1110, where the method determines a position of the user's shoulders and a position of the user's chest in the frame based on the location of the user's face and the position of the convex hull. Next, at 1112, the method determines a posture of the user based on relative positions of the user's face, the user's shoulders and the user's chest. The method then goes to A, with a continued description in FIG. 11B.

FIG. 11B is a continued description of method 1100. Starting at A, the method goes to 1114, where the method tracks the posture of the user with respect to time using the posture tracking methods described herein. At 1116 the method checks to see whether the posture of the user is substantially different from a predetermined posture. If the posture of the user is not substantially different from the predetermined posture then the method goes to B, and returns back to 1102. On the other hand if, at 1116, the posture of the user is substantially different from the predetermined posture then the method goes to 1118, where the method alerts the user if the posture of the user is substantially different from the predetermined reference posture using at least one of an audible alert or a visual alert.

FIG. 12A represents a flow diagram depicting an embodiment of a method 1200 to characterize a user's posture. At 1202, the method receives visual data associated with a user's head, shoulders and chest. In some embodiments, the visual data may be received by processing system 102 from imaging device 106. At 1204, the method determines a largest blob in a frame associated with the visual data. Next, at 1206, the method determines a convex hull of a contour associated with a largest blob. The process of determining the largest blob and associated convex hull is performed using methods described earlier.

At 1208, the method detects the user's face in the convex hull using, for example, OpenCV or frontal face and eye cascades. Next, at 1210, the method determines the presence of the user's face in the frame. At 1212, the method determines a position of the center of the user's head based on the position of the user's face,

while at 1214 the method determines a position of the bottom of the user's head. The method then goes to A, with a continued description provided subsequently.

FIG. 12B is a continued description of the method 1200. Starting at A, the method goes to 1216, where the method determines a position of the user's left shoulder based on the convex hull. Next, at 1218, the method determines a position of the user's right shoulder based on the convex hull. In some embodiments, the position of the user's left shoulder and the position of the user's right shoulder are determined based on user motion, with the user swaying side-to-side. Using image recognition or computer vision algorithms, the user's left shoulder is located by finding the center of the user's head and the bottom of the user's head within the user motion region and then splitting the user motion region in half wherein the left side portion of the user motion region located beneath the head and to the left of the center of the head is considered the left shoulder. Though this region will contain non-shoulder data due to the user movement, it will still be able to use this shoulder data to find the shoulder in the posture tracking step. Similarly, the user's right shoulder is located by finding the center of the user's head and the bottom of the user's head within the user motion region and then splitting the user motion region in half wherein the right side portion of the user motion region located beneath the head and to the right of the center of the head is considered the right shoulder. Though this region will contain non-shoulder data due to the user movement, it will still be able to use this shoulder data to find the shoulder in the posture tracking step.

Finally, at 1220, the method characterizes the user's posture using the position of the user's face, the position of the user's left shoulder, and the position of the user's right shoulder.

FIG. 13 is a schematic diagram illustrating an embodiment of an application 1300 of posture tracking system 100 in an airplane cabin 1302. In some embodiments, a user 1304 may install and run posture tracking system 100 on a mobile device 1306 and place (or mount) the mobile device on the back of the seat in front of the user as shown in FIG. 13. In some embodiments, a user mobile device such as a mobile phone or a tablet may be mounted on the back of the seat in front of the user using plastic clips. In some embodiments, a user may place their laptop computer with integrated webcam on top of a tray table in front of the user. User 1304 may initialize posture tracking system 100 with a predetermined posture using the built-in camera of mobile device 1306. Then, posture tracking system 100 can track the posture of user 1304 for the period of the journey or for a time period specified by the user.

FIG. 14 is a schematic diagram illustrating an embodiment of another application 1400 of posture tracking system 100 in an automobile or other vehicle to provide a posture tracking feature for the driver of the automobile. FIG. 14 shows a vehicle instrument cluster 1402, with posture tracking system 100 providing posture feedback to a driver of the vehicle on a vehicle display 1404. Some embodiments may use a mounted camera on the vehicle dashboard in front of the user to monitor the user's posture, while some embodiments may use a camera that is installed in the vehicle dashboard to monitor the user's posture.

Other embodiments of posture analysis system 100 may include an implementation in an operating room where an imaging device is focused on the doctor or other personnel and is coupled to a computing system and associated display device to provide posture feedback to the doctor or other personnel. This system would provide feedback for situations such as when a user's shoulders are not square to the floor for extended time (shrugging). Also a user having their arms in fixed positions for long periods of time (either totally straight or elbows bent) may be addressed by posture analysis system 100. General slouching (downward movement of body from an initial good posture position) may also be accounted for. The imaging device facing the doctor could be a laptop or webcam or phone/tablet placed on a moveable arm tray positioned above the patient in the line of sight of the doctor, or anywhere that is doctor facing as long as the doctor's face is within the field of view of the imaging device.

Although the present disclosure is described in terms of certain example embodiments, other embodiments will be apparent to those of ordinary skill in the art, given the benefit of this disclosure, including embodiments that do not provide all of the benefits and features set forth herein, which are also within the scope of this disclosure. It is to be understood that other embodiments may be utilized, without departing from the scope of the present disclosure.

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