BED HAVING FEATURES FOR ESTIMATING CORE BODY TEMPURATURES FROM SENSING OF CARDIAC PARAMETERS AND EXTERNAL TEMPERATURE

[0001] The present document relates to beds with computer hardware.

CROSS-REFERENCE TO RELATED APPLICATIONS

[0002] This application claims the benefit of U.S. Provisional Application Serial No. 63/185,211, filed May 6, 2021. The disclosure of the prior application is considered part of (and is incorporated by reference in) the disclosure of this application.

BACKGROUND

[0003] In general, a bed is a piece of furniture used as a location to sleep or relax. Many modern beds include a soft mattress on a bed frame. The mattress may include springs, foam material, and/or an air chamber to support the weight of one or more occupants.

SUMMARY

[0003a] According to a first aspect of the present invention, there is provided a system with features to estimate core temperature of a sleeper of a bed, the system comprising:

a bed having a mattress;

one or more temperature sensors, each sensor configured to:

sense a temperature for the sleeper; and

transmit, to a controller, temperature readings;

one or more pressure sensors, each pressure sensor configured to:

sense a pressure applied to the mattress by the sleeper; and

transmit, to the controller, pressure readings;

the controller comprising a processor and memory, the controller configured to:

receive, from the temperature sensors, the temperature readings;

determine a skin temperature for the sleeper based on the temperature readings;

receive, from the pressure sensors, the pressure readings;

determine at least one cardiac parameter for the sleeper; and

determine, from the skin temperature and the cardiac parameter, a core temperature for the sleeper that is different than the skin temperature and represents thermal state of a core of a body of the sleeper,

wherein to determine, from the skin temperature and the cardiac parameter, the core temperature for the sleeper, the controller is configured to use a first core-determining function configured to:

receive the skin temperature and the cardiac parameter as input;

apply the input to a model that specifies a relationship; and

receive, from the core-determining function, the core temperature,

wherein the first core-determining function is selected from a plurality of possible core-determining functions based on a core-determining function begin associated with a subpopulation to which the sleeper belongs.

[0003b] According to a second aspect of the present invention, there is provided a method of estimating core temperature of a sleeper of a bed, the method comprising:

receiving, from one or more temperature sensors of a bed, the temperature readings;

determining a skin temperature for the sleeper based on the temperature readings;

receiving, from the pressure sensors of the bed, the pressure readings;

determining at least one cardiac parameter for the sleeper; and

determining, from the skin temperature and the cardiac parameter, a core temperature for the sleeper that is different than the skin temperature and represents thermal state of a core of a body of the sleeper,

wherein determining, from the skin temperature and the cardiac parameter, the core temperature for the sleeper comprises using a first core-determining function comprising:

receiving the skin temperature and the cardiac parameter as input;

applying the input to a model that specifies a relationship; and

receiving, from the core-determining function, the core temperature,

wherein the first core-determining function is selected from a plurality of possible core-determining functions based on a core-determining function begin associated with a subpopulation to which the sleeper belongs.

[0003c] According to a third aspect of the present invention, there is provided a non-transitory computer-readable medium storing instructions that, the instructions being executable by one or more processors to cause the processors to perform operations comprising:

receiving, from one or more temperature sensors of a bed, the temperature readings;

determining a skin temperature for the sleeper based on the temperature readings;

receiving, from the pressure sensors of the bed, the pressure readings;

determining at least one cardiac parameter for the sleeper; and

determining, from the skin temperature and the cardiac parameter, a core temperature for the sleeper that is different than the skin temperature and represents thermal state of a core of a body of the sleeper,

wherein determining, from the skin temperature and the cardiac parameter, the core temperature for the sleeper comprises using a first core-determining function comprising:

receiving the skin temperature and the cardiac parameter as input;

applying the input to a model that specifies a relationship; and

receiving, from the core-determining function, the core temperature,

wherein the first core-determining function is selected from a plurality of possible core-determining functions based on a core-determining function begin associated with a subpopulation to which the sleeper belongs.

[0004]

[0005] In general, this document describes technology for controlling and a system of one or more computers can be configured to perform particular operations or actions by virtue of having software, firmware, hardware, or a combination of them installed on the system that in operation causes or cause the system to perform the actions. One or more computer programs can be configured to perform particular operations or actions by virtue of including instructions that, when executed by data processing apparatus,

cause the apparatus to perform the actions. One general example to estimate core temperature of a sleeper of a bed may include: a bed having a mattress; one or more temperature sensors, each sensor configured to: sense a temperature for the sleeper; and transmit, to a controller, temperature readings; one or more pressure sensors, each pressure sensor configured to: sense a pressure applied to the mattress by the sleeper; and transmit, to a controller, pressure readings; a controller may include a processor and memory, the controller configured to: receive, from the temperature sensors,

the temperature readings; determine a skin temperature for the sleeper based on the temperature readings; receive, from the pressure sensors, the pressure readings; determine at least one cardiac parameter for the sleeper; and determine, from the skin temperature and the cardiac parameter, a core temperature for the sleeper that is different than the skin temperature and represents thermal state of a core of a body of the sleeper. Other embodiments of this example include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0006] Implementations may include one or more of the following features. The skin temperature and the core temperature of the sleeper are recorded separately to computer memory in association with an identifier of the sleeper. To determine, from the skin temperature and the cardiac parameter, the core temperature for the sleeper, the controller is configured to: weigh cardiac parameter by a first weight; and weigh the core temperature by a second weight. To determine, from the skin temperature and the cardiac parameter, the core temperature for the sleeper, the controller is configured to use an equation: core temperature for the sleeper = k0 + k1* the skin temperature + k2* the cardiac parameter, where k1 is the first weight and k2 is the second weight and k0 is a third weight. Where k0, k1, and k2 are selected based on a characteristic of the sleeper. To determine, from the skin temperature and the cardiac parameter, the core temperature for the sleeper, the controller is configured to use a first core-determining function configured to: receive the skin temperature and the cardiac parameter as input; apply the input to a model that specifies a relationship receive, from the core-determining function, the core temperature. The first core-determining function is selected from a plurality of possible core-determining function based on the core-determining function begin associated with a subpopulation to which the sleeper belongs. The subpopulation is defined using at least one of the group of age, sex, health status, athletic status, critical status, and sleep environment. Where a second core-determining function of the plurality of possible core-determining function is configured to provide different core temperature for the sleeper than the first core-determining function when provided with the same input as the first value generator. The controller is further configured to determine, from at least one of the temperature readings and the pressure readings,

decreases by ~5 bpm. This technology is able to sense these changes unobtrusively, unlike other technology requiring sensors attached to a subject's body or other sensing modalities that require the subject to wear a sensor or alter their normal evening routine before going to bed.

[0011] Other features, examples and potential advantages will be apparent from the accompanying description and figures.

DESCRIPTION OF DRAWINGS

[0012] FIG. 1 shows an example air bed system.

[0013] FIG. 2 is a block diagram of an example of various components of an air bed system.

[0014] FIG. 3 shows an example environment including a bed in communication with devices located in and around a home.

[0015] FIGs. 4A and 4B are block diagrams of example data processing systems that can be associated with a bed.

[0016] FIGs. 5 and 6 are block diagrams of examples of motherboards that can be used in a data processing system that can be associated with a bed.

[0017] FIG. 7 is a block diagram of an example of a daughterboard that can be used in a data processing system that can be associated with a bed.

[0018] FIG. 8 is a block diagram of an example of a motherboard with no daughterboard that can be used in a data processing system that can be associated with a bed.

[0019] FIG. 9 is a block diagram of an example of a sensory array that can be used in a data processing system that can be associated with a bed.

[0020] FIG. 10 is a block diagram of an example of a control array that can be used in a data processing system that can be associated with a bed

[0021] FIG. 11 is a block diagram of an example of a computing device that can be used in a data processing system that can be associated with a bed.

[0022] FIGs. 12-16 are block diagrams of example cloud services that can be used in a data processing system that can be associated with a bed.

WHAT IS CLAIMED IS:

1. A system with features to estimate core temperature of a sleeper of a bed, the system comprising:

    a bed having a mattress;

    one or more temperature sensors, each sensor configured to:

        sense a temperature for the sleeper; and

        transmit, to a controller, temperature readings;

    one or more pressure sensors, each pressure sensor configured to:

        sense a pressure applied to the mattress by the sleeper; and

        transmit, to the controller, pressure readings;

    the controller comprising a processor and memory, the controller configured to:

        receive, from the temperature sensors, the temperature readings;

        determine a skin temperature for the sleeper based on the temperature readings;

        receive, from the pressure sensors, the pressure readings;

        determine at least one cardiac parameter for the sleeper; and

        determine, from the skin temperature and the cardiac parameter, a core temperature for the sleeper that is different than the skin temperature and represents thermal state of a core of a body of the sleeper,

    wherein to determine, from the skin temperature and the cardiac parameter, the core temperature for the sleeper, the controller is configured to use a first core-determining function configured to:

        receive the skin temperature and the cardiac parameter as input;

        apply the input to a model that specifies a relationship; and

        receive, from the core-determining function, the core temperature,

    wherein the first core-determining function is selected from a plurality of possible core-determining functions based on a core-determining function begin associated with a subpopulation to which the sleeper belongs.

2. The system of claim 1, wherein the skin temperature and the core temperature of the sleeper are recorded separately to computer memory in association with an identifier of the sleeper.

3. The system of claim 1, wherein to determine, from the skin temperature and the cardiac parameter, the core temperature for the sleeper, the controller is configured to:

    weigh cardiac parameter by a first weight; and

    weigh the core temperature by a second weight.

4. The system of claim 3, wherein to determine, from the skin temperature and the cardiac parameter, the core temperature for the sleeper, the controller is configured to use an equation:

core temperature for the sleeper = k0 + k1* the skin temperature + k2* the cardiac parameter, where k1 is the first weight and k2 is the second weight and k0 is a third weight.

5. The system of claim 4, wherein k0, k1, and k2 are selected based on a characteristic of the sleeper.

6. The system of claim 1, wherein the subpopulation is defined using at least one of the group consisting of age, sex, health status, athletic status, critical status, and sleep environment.

7. The system of claim 1, wherein a second core-determining function of the plurality of possible core-determining function is configured to provide different core temperature for the sleeper than the first core-determining function when provided with the same input as the first core-determining function.

8. The system of claim 1, wherein the controller is further configured to determine, from at least one of the temperature readings and the pressure readings, that the sleeper is present in the bed.

9. The system of claim 1 wherein the controller is configured to determine a sleep state and, based on the determined sleep state, limit the determination of the core temperature to be no greater than a threshold value.

10. The system of claim 1, wherein the controller is configured to perform at least one of the group consisting of:

storing the core temperature for the sleeper to a computer memory;

displaying the core temperature for the sleeper on a display;

engaging, in response to determining the core temperature for the sleeper, an automated device;

engaging, in response to determining the core temperature for the sleeper, an alert in a first environment of the sleeper; and

engaging, in response to determining the core temperature for the sleeper, an alert in a second environment of a caregiver separate from the first environment.

11. The system of claim 1, the system further comprising a humidity sensor configured to sense humidity for the sleeper caused by sleeper sweat; and

wherein to determine, from the skin temperature and the cardiac parameter, a core temperature for the sleeper that is different than the skin temperature and represents thermal state of a core of a body of the sleeper, the controller is configured to determine, from the skin temperature, the cardiac parameter and the sensed humidity, a core temperature for the sleeper that is different than the skin temperature and represents thermal state of a core of a body of the sleeper.

12. A method of estimating core temperature of a sleeper of a bed, the method comprising:

receiving, from one or more temperature sensors of a bed, the temperature readings;

determining a skin temperature for the sleeper based on the temperature readings;

receiving, from the pressure sensors of the bed, the pressure readings;

determining at least one cardiac parameter for the sleeper; and

determining, from the skin temperature and the cardiac parameter, a core temperature for the sleeper that is different than the skin temperature and represents thermal state of a core of a body of the sleeper,

wherein determining, from the skin temperature and the cardiac parameter, the core temperature for the sleeper comprises using a first core-determining function comprising:

receiving the skin temperature and the cardiac parameter as input;

applying the input to a model that specifies a relationship; and

receiving, from the core-determining function, the core temperature,

wherein the first core-determining function is selected from a plurality of possible core-determining functions based on a core-determining function begin associated with a subpopulation to which the sleeper belongs.

13. The method of claim 12, wherein the skin temperature and the core temperature of the sleeper are recorded separately to computer memory in association with an identifier of the sleeper.

14. The method of claim 12, wherein determining, from the skin temperature and the cardiac parameter, the core temperature for the sleeper comprises:

weighing cardiac parameter by a first weight; and

weighing the core temperature by a second weight.

15. The method of claim 14, wherein determining, from the skin temperature and the cardiac parameter, the core temperature for the sleeper comprises use of an equation:

core temperature for the sleeper = k0 + k1* the skin temperature + k2* the cardiac parameter, where k1 is the first weight and k2 is the second weight and k0 is a third weight.

16. A non-transitory computer-readable medium storing instructions that, the instructions being executable by one or more processors to cause the processors to perform operations comprising:

receiving, from one or more temperature sensors of a bed, the temperature readings;

determining a skin temperature for the sleeper based on the temperature readings;

receiving, from the pressure sensors of the bed, the pressure readings;

determining at least one cardiac parameter for the sleeper; and

determining, from the skin temperature and the cardiac parameter, a core temperature for the sleeper that is different than the skin temperature and represents thermal state of a core of a body of the sleeper,

wherein determining, from the skin temperature and the cardiac parameter, the core temperature for the sleeper comprises using a first core-determining function comprising:

receiving the skin temperature and the cardiac parameter as input;

applying the input to a model that specifies a relationship; and

receiving, from the core-determining function, the core temperature,

wherein the first core-determining function is selected from a plurality of possible core-determining functions based on a core-determining function begin associated with a subpopulation to which the sleeper belongs.

17. The medium of claim 16, wherein the skin temperature and the core temperature of the sleeper are recorded separately to computer memory in association with an identifier of the sleeper.

18. The medium of claim 16, wherein determining, from the skin temperature and the cardiac parameter, the core temperature for the sleeper comprises:

weighing cardiac parameter by a first weight; and

weighing the core temperature by a second weight.