CLAIMS

~~What is claimed is:~~

1. A device for detecting sleep apnea events of a user, comprising:

a first sensor for capturing snoring sound of the user;

a second sensor for capturing cardiovascular parameters of the user;

a third sensor for capturing breathing movements of the user;

a data recorder that is connected with the first sensor, the second sensor and the third sensor for recording measurements therefrom~~,~~; and

a clock for synchronizing the ~~recordings~~ measurements,

wherein a dual spike comprises a heart rate spike that occurs simultaneously with a SPO2 spike;

wherein the ~~recordings~~ measurements include one or more breathing events that comprise~~s~~ snoring events, ~~heart rate and SPO_2 conjunction~~ one or more of the dual spikes, and breathing movement cessations~~,~~; and

~~whereby~~ a signal processing unit that excludes time periods that apnea events are impossible ~~can be excluded~~ according to a combination of the breathing events, ~~and~~ so that detection of the apnea events ~~can be detected thereafter~~ is expedited,

wherein the excluded time periods that the apnea events are impossible include:

a time period of each of the snoring events;

a time period between two of the snoring events that is less than a pre-determined length of time;

a time period between one of the dual spikes and one of the snoring events that is less than the pre-determined length of time;

a time period between two of the dual spikes that is less than the pre-determined length of time; and

a time period of the breathing movement cessations that is less than the pre-determined length of time;

wherein the third sensor further comprises:

an optic fiber;

an upper frame that is stiff; and

a lower frame that is stiff and includes protrusions for holding the optic fiber therebetween,

wherein the optic fiber is sandwiched between the upper frame and the lower frame, so that the optic fiber generates light loss corresponding to the breathing movements of the user when the user is lying on the upper frame.

2. The device of claim 1, wherein the first sensor includes at least one microphone and a low-pass filter that connects with the at least one microphone, and the second sensor includes a pulse oximeter.

~~3. The device of claim 1, wherein the third sensor further comprising:~~

~~an optic fiber;~~

~~an upper frame that is stiff; and~~

~~a lower frame that is stiff and includes protrusions for holding the optic fiber therebetween,~~

~~wherein the optic fiber is sandwiched between the upper frame and the lower frame, so that the optic fiber generates light loss corresponding to the breathing movements of the user when the user is lying on the upper frame.~~

~~4.~~3. The device of claim 1, wherein one or more of the first, second, and third sensors communicate with the data recorder by wireless transmission.

~~5.~~4. The device of claim ~~6~~3, further comprising:

a sleeve that covers ~~the~~ one or more of the first, second, and third sensors and the data recorder, wherein the sleeve is made of a radiofrequency (RF) absorbent material.

~~6.~~5. A system for ~~detecting~~ expediting detection of apnea events of a user, comprising:

a first sensor configured to capture snoring sound of the user;

a second sensor configured to capture cardiovascular parameters of the user;

a third sensor configured to capture breathing movements of the user;

wherein the third sensor further comprises:

an optic fiber;

an upper frame that is stiff; and

a lower frame that is stiff and includes protrusions for holding the optic fiber,

wherein the optic fiber meanders between the upper frame and the lower frame, so that the optic fiber generates light loss corresponding to the breathing movements of the user lying on the upper frame;

a data recorder configured to record measurements of the first sensor, the second sensor and the third sensor, and synchronize the measurements; and

a computer system that includes a processor and a non-transient computer-readable storage medium,

wherein the storage medium stores thereon instructions that when executed cause the processor to:

receive the measurements from the data recorder;

extract one or more breathing events including snoring events, ~~heart rate and SPO_2~~ conjunction spikes, wherein each conjunction spike is a heart rate spike that occurs simultaneously with a SPO2 spike, and breathing movement cessations from the measurements;

exclude time periods that an apnea event is impossible according to a combination of the breathing events; and

detect the apnea events outside the excluded time periods, wherein the excluded time periods that the apnea events are impossible include:

one or more time periods of the snoring events;

one or more time periods between two of the snoring events that are less than a pre-determined length of time;

one or more time periods between one of the conjunction spikes and one of the snoring events that are less than the pre-determined length of time;

one or more time periods between two of the conjunction spikes that are less than the pre-determined length of time; and

one or more time periods of the breathing movement cessations that are less than the pre-determined length of time.

~~7. The system of claim 6, wherein the instructions when executed further cause the processor to:~~

~~exclude one or more time period of snoring events.~~

~~8. The system of claim 6, wherein the instructions when executed further cause the processor to:~~

~~exclude one or more time period between two snoring event that is less than a pre-determined length of time.~~

~~9. The system of claim 6, wherein the instructions when executed further cause the processor to:~~

~~exclude one or more time periods between one conjunction spike and a snoring event that is less than a pre-determined length of time.~~

~~10. The system of claim 6, wherein the instructions when executed further cause the processor to:~~

~~exclude one or more time periods between two conjunction spikes that is less than a pre-determined length of time.~~

~~11.~~6. The system of claim ~~6~~5, wherein the instructions when executed further cause the processor to:

count one apnea event outside the excluded time periods when ~~a~~ one of the breathing movement cessations that is outside the excluded time periods lasts ~~greater~~ longer than ~~a~~ the pre-determined length of time before ~~a~~ one of the conjunction spikes that is outside the excluded time periods appears.

~~12. The system of claim 6, wherein the third sensor further comprising:~~

~~an optic fiber;~~

~~an upper frame that is stiff; and~~

~~a lower frame that is stiff and includes protrusions for holding the optic fiber, wherein the optic fiber meanders between the upper frame and the lower frame, so that the optic fiber generates light loss corresponding to the breathing movements of the user lying on the upper frame.~~

~~13.~~7. A system that expedites detecting apnea events of a user, comprising:

a sensing unit that captures one or more of a snoring sound of the user, a heart rate and a SPO2 value of the user, and a breathing movement of the user;

wherein a conjunction spike is a heart rate spike that occurs simultaneously with a SPO2 spike;

a data recorder that includes a clock and connects with the sensing unit, wherein the data recorder records measurements from the sensing unit and synchronizes the measurements in time by the clock; and

a signal processing unit that extracts breathing events from the synchronized measurements, ~~and~~ wherein the breathing events include snoring events, conjunction spikes, and breathing movement cessation, and that excludes time periods that an apnea event is impossible according to the breathing events so that ~~the~~ detection of the apnea events is expedited,

wherein the excluded time periods that the apnea events are impossible include:

a time period of each of the snoring events;

a time period between two of the snoring events that is less than a pre-determined length of time;

a time period between one of the conjunction spikes and one of the snoring events that is less than the pre-determined length of time;

a time period between two of the conjunction spikes that is less than the pre-determined length of time; and

a time period of the breathing movement cessations that is less than the pre-determined length of time

wherein the sensing unit further comprises:

an optic fiber;

an upper frame that is stiff; and

a lower frame that is stiff and includes protrusions for holding the optic fiber therebetween,

wherein the optic fiber is sandwiched between the upper frame and the lower frame, so that the optic fiber generates light loss corresponding to the breathing movements of the user when the user is lying on the upper frame.

~~14. The system of claim 13, wherein the breathing events includes one or more of a snoring event, a heart rate and SPO_2 conjunction spike and a breathing movement cessation.~~

~~15. The system of claim 14, wherein the signal processing unit excludes one or more time periods including:~~

~~time period of each snoring event,~~

~~time period between two snoring events that is less than a pre-determined length of time;~~

~~time period between a conjunction spike and a snoring event that is less than the pre-determined length of time,~~

~~time period between two conjunction spikes that is less than the pre-determined length of time, and~~

~~time period of the breathing movement cessation that is less than the pre-determined length of time.~~

~~16.~~8. The system of claim ~~15~~7, wherein the signal processing unit counts one apnea event outside the excluded time periods when ~~a~~ one of the breathing movement cessations outside the excluded time periods lasts ~~greater~~ longer than the pre-determined length of time before ~~a~~ one of the conjunction spikes outside the excluded time periods appears.

~~17.~~9. A method executed by a computer for ~~detecting~~ expediting detection of apnea events of a user, comprising:

receiving, by the computer, measurements captured from a plurality of sensors when the user is sleeping, wherein the measurements include snoring sounds, cardiovascular parameters and breathing movements of the user, and the measurements are synchronized by a clock;

using an optic fiber that is sandwiched between an upper frame and a lower frame so that the optic fiber generates light loss corresponding to the breathing movements of the user when the user is lying on the upper frame;

extracting, by the computer, a plurality of breathing events from the measurements, including snoring events, heart rate and SPO2 conjunction spikes, and breathing movement cessations;

~~excluding, by the computer, time periods that an apnea is impossible according to a combination of the breathing events;~~

~~detecting, by the computer, the apnea events outside the excluded time periods~~wherein each heart rate and SPO2 conjunction spike is a heart rate peak that occurs simultaneously in time with a SPO2 peak;

excluding, by the computer, time periods that an apnea event is impossible according to a combination of the breathing events;

detecting, by the computer, the apnea events outside the excluded time periods that the apnea events are impossible,

wherein the excluded time periods that the apnea events are impossible include:

a time period of each of the snoring events;

a time period between two of the snoring events that is less than a pre-determined length of time;

a time period between one of the heart rate and SPO2 conjunction spikes and one of the snoring events that is less than the pre-determined length of time;

a time period between two of the heart rate and SPO2 conjunction spikes that is less than the pre-determined length of time; and

a time period of the breathing movement cessations that is less than the pre-determined length of time.

~~18. The method of claim 17, further comprising:~~

~~excluding, by the computer, one or more time periods including:~~

~~time period of each snoring event,~~

~~time period between a conjunction spike and a snoring event that is less than a pre-determined length of time,~~

~~time period between two conjunction spikes that is less than the pre-determined length of time, and~~

~~time period of the breathing movement cessation that is less than the pre-determined length of time.~~

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~~19.~~10. The method of claim ~~17~~9, further comprising:

counting, by the computer, one apnea event outside the excluded time periods when ~~a~~ one of the breathing movement cessations outside the excluded time periods lasts ~~greater~~ longer than ~~a~~ the pre-determined length of time before

~~a~~ one of the heart rate and SPO2 conjunction spikes outside the excluded time periods appears.

~~20.~~11. The method of claim ~~17~~9, further comprising:

counting, by the computer, a number of the apnea events per hour.