US 20200085301A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2020/0085301 A1**

Reinhardt et al. (43) **Pub. Date: Mar. 19, 2020**

(54) **EDGE-INTELLIGENT IOT-BASED WEARABLE DEVICE FOR DETECTION OF CRAVINGS IN INDIVIDUALS**

(71) Applicants: **Megan Reinhardt**, Bristol, MA (US); **Nicole Gilbertson**, Huntington Beach, CA (US); **Premananda Indic**, Whitehouse, TX (US); **Prabha Sundaravadivel**, Murphy, TX (US)

(72) Inventors: **Megan Reinhardt**, Bristol, MA (US); **Nicole Gilbertson**, Huntington Beach, CA (US); **Premananda Indic**, Whitehouse, TX (US); **Prabha Sundaravadivel**, Murphy, TX (US)

(21) Appl. No.: **16/688,861**

(22) Filed: **Nov. 19, 2019**

Related U.S. Application Data

(63) Continuation-in-part of application No. 15/681,111, filed on Aug. 18, 2017, now Pat. No. 10,478,066.

Publication Classification

(51) **Int. Cl.**

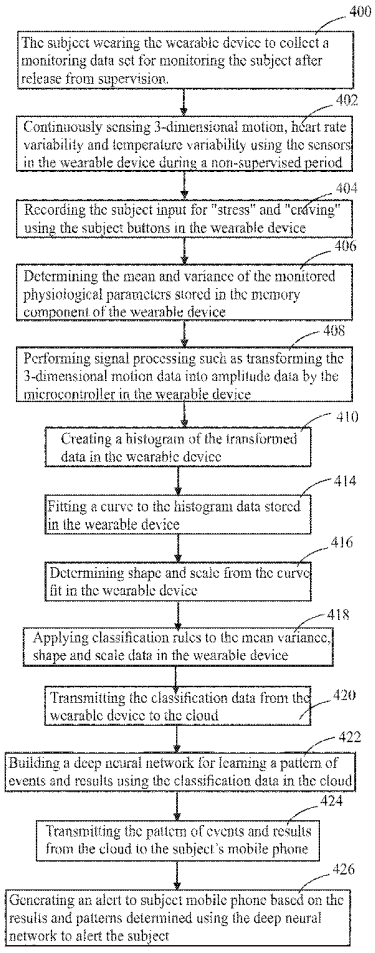
A61B 5/00	(2006.01)
G06K 19/077	(2006.01)
A61B 5/0205	(2006.01)
G16H 40/63	(2006.01)
G06F 1/16	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 5/0022*** (2013.01); ***G06K 19/07762*** (2013.01); ***G06F 1/163*** (2013.01); ***G16H 40/63*** (2018.01); ***A61B 5/0205*** (2013.01)

(57) **ABSTRACT**

A wearable physiological monitoring system comprises commercially available off-the shelf components. With the growth of interrelated systems of computing devices, mechanical and digital machines, objects, animals or people connected by the Internet, there is a significant interest in the use of wearable sensors such as cell watches, and cell phones. These wearable sensors may be used to monitor physiological signals and provide health information. An edge-intelligent Internet based wearable assists in substance-abuse detection by monitoring and interpreting an individual's physiological signals on continuous basis. The wearable device helps in monitoring cravings and substance abuse of the individual and help the healthcare provider to start an early intervention as required. The proposed system is developed as a dedicated substance abuse wearable system. An example of a wearable device is a medical quality wearable which yielded a correlation of 0.89 for accelerometer measurements and 0.92 for average heart rate measurements in tests.



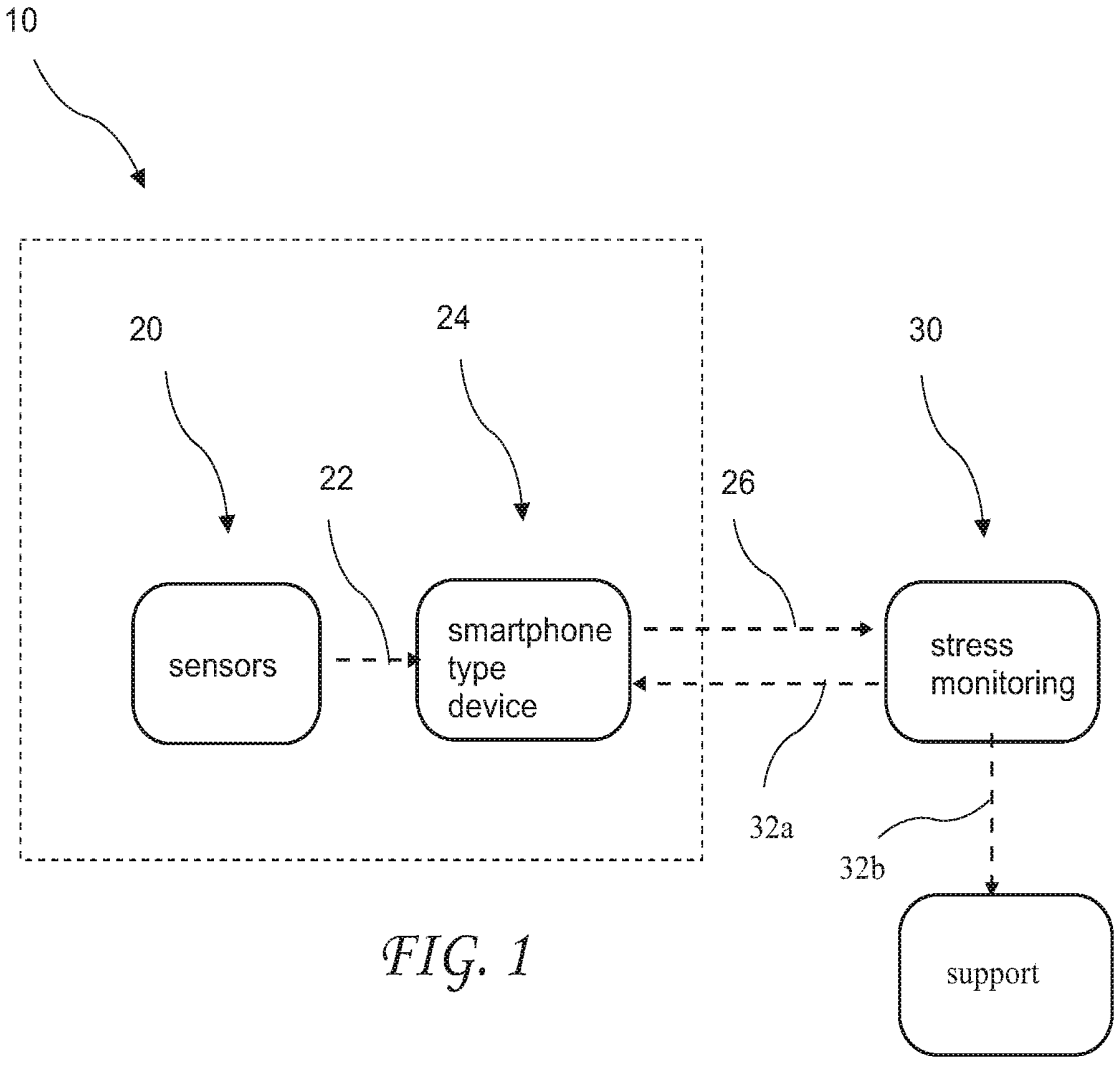

10
20
24
30
22
26
sensors
smartphone type device
stress monitoring
32a
32b
support

FIG. 1

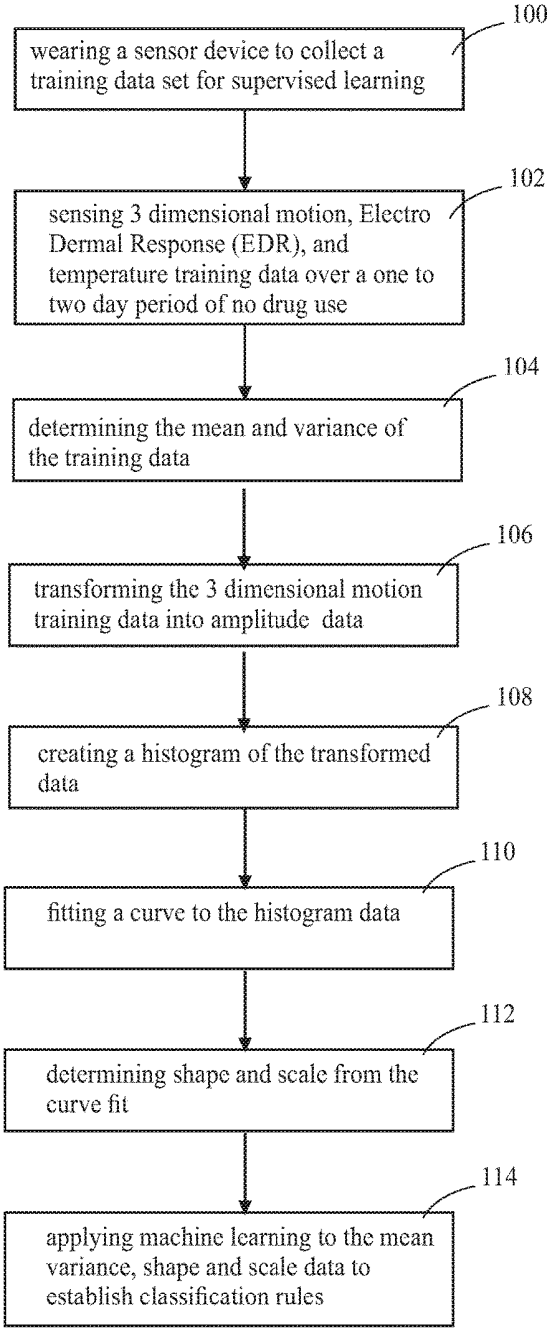

wearing a sensor device to collect a training data set for supervised learning
100
sensing 3 dimensional motion, Electro Dermal Response (EDR), and temperature training data over a one to two day period of no drug use
102
determining the mean and variance of the training data
104
transforming the 3 dimensional motion training data into amplitude data
106
creating a histogram of the transformed data
108
fitting a curve to the histogram data
110
determining shape and scale from the curve fit
112
applying machine learning to the mean variance, shape and scale data to establish classification rules
114

FIG. 2

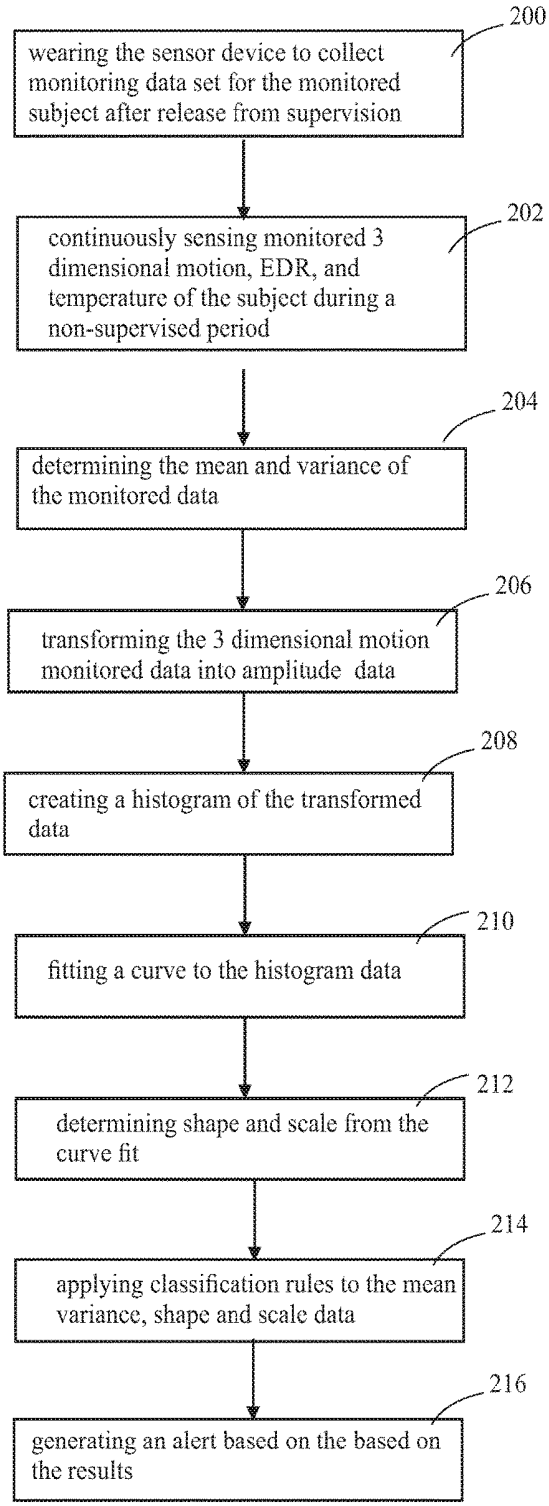

wearing the sensor device to collect monitoring data set for the monitored subject after release from supervision
200
continuously sensing monitored 3 dimensional motion, EDR, and temperature of the subject during a non-supervised period
202
determining the mean and variance of the monitored data
204
transforming the 3 dimensional motion monitored data into amplitude data
206
creating a histogram of the transformed data
208
fitting a curve to the histogram data
210
determining shape and scale from the curve fit
212
applying classification rules to the mean variance, shape and scale data
214
generating an alert based on the based on the results
216

FIG. 3

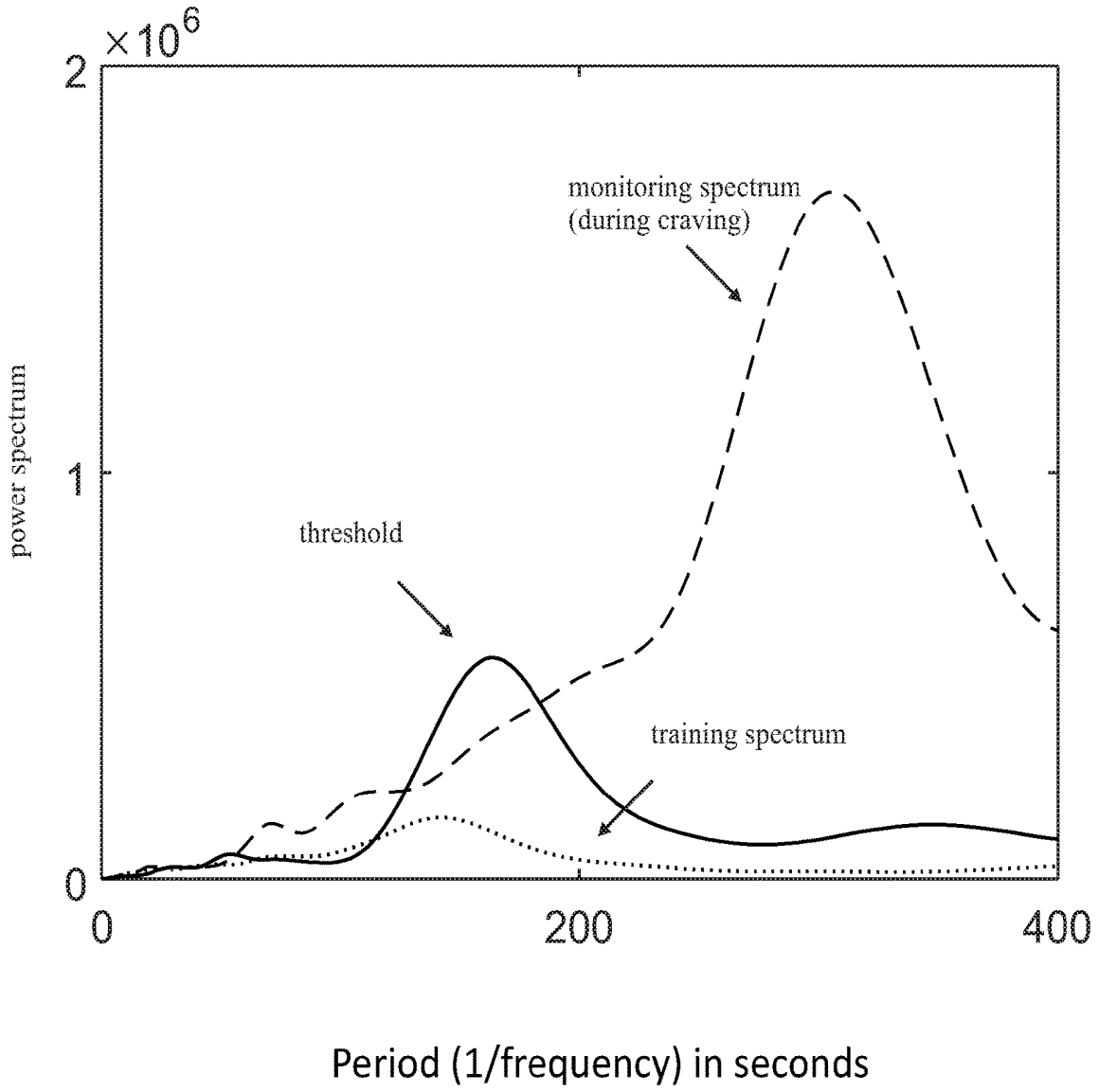

×10^6
2
1
0
power spectrum
monitoring spectrum
(during craving)
threshold
training spectrum
0
200
400
Period (1/frequency) in seconds

FIG. 4

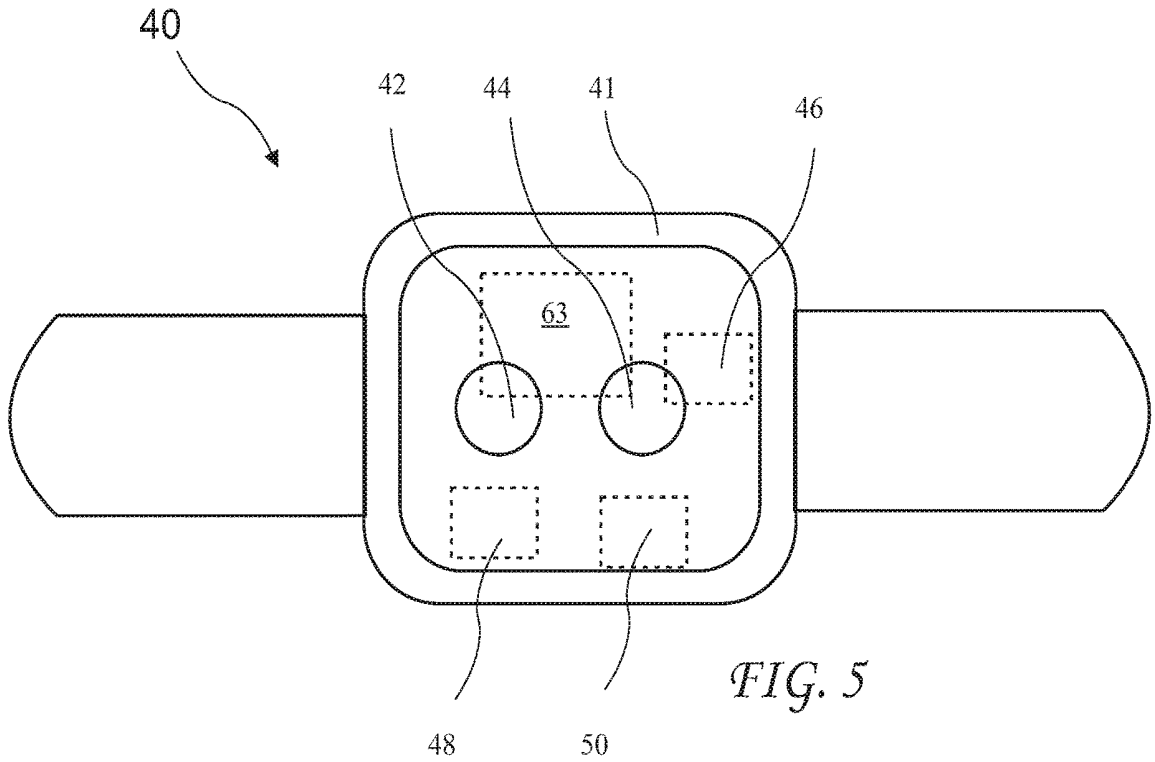

40
42
44
41
46
63
48
50

FIG. 5

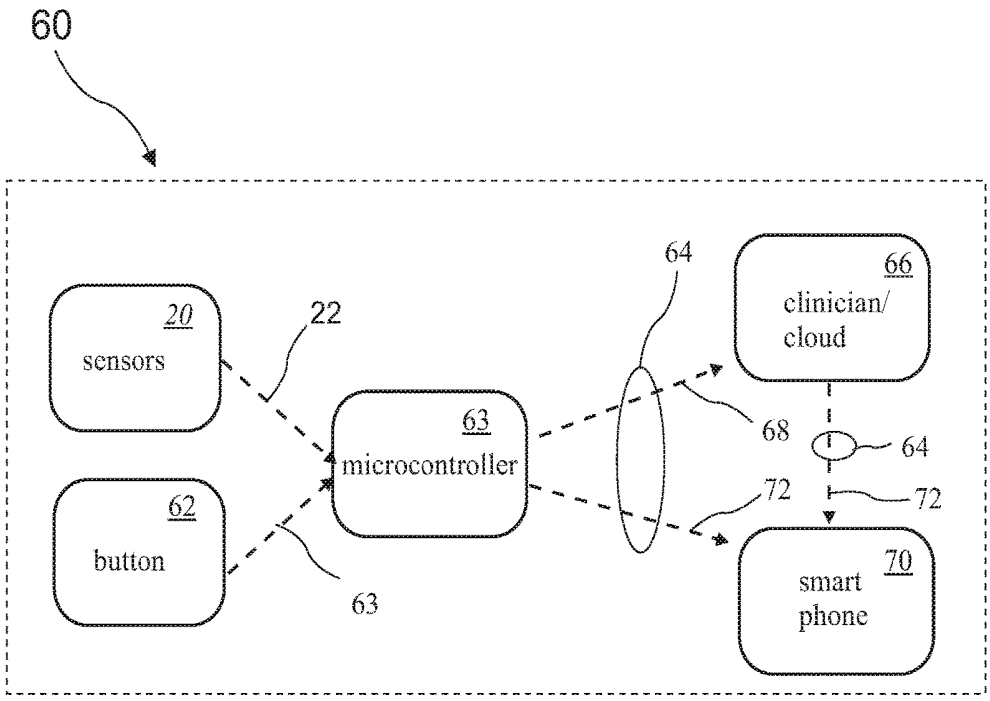

60
20
sensors
22
62
button
63
microcontroller
63
64
66
clinician/
cloud
68
64
72
72
70
smart
phone

FIG. 6

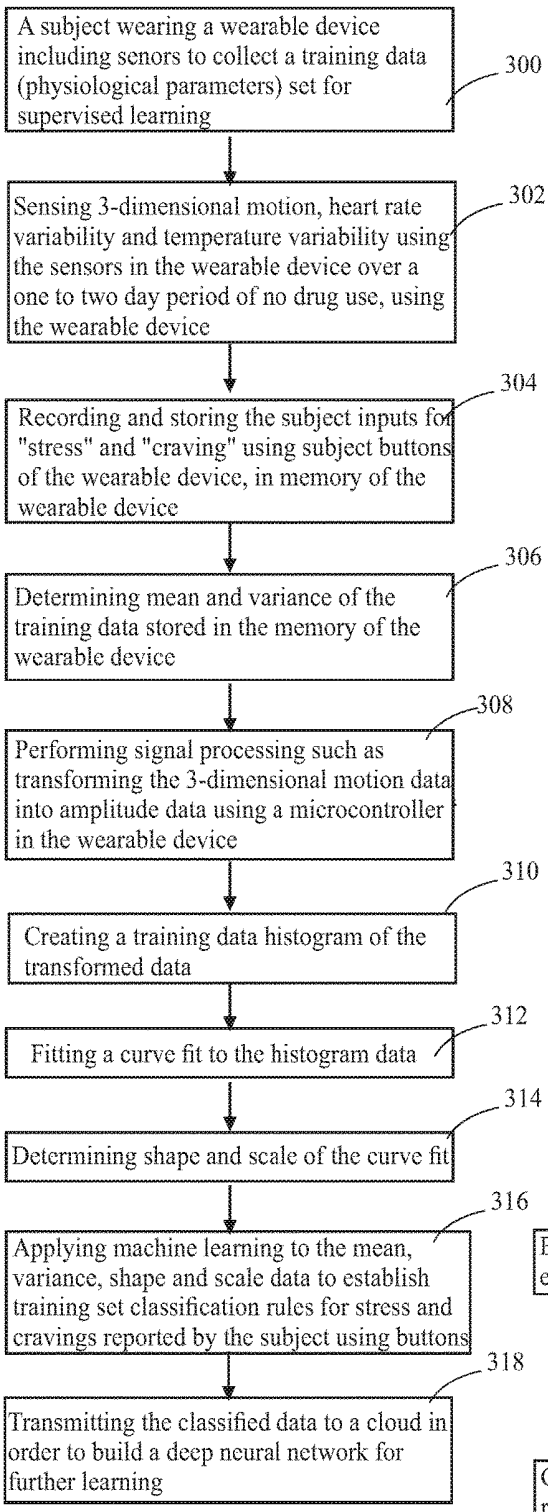

A subject wearing a wearable device including senors to collect a training data (physiological parameters) set for supervised learning
300
Sensing 3-dimensional motion, heart rate variability and temperature variability using the sensors in the wearable device over a one to two day period of no drug use, using the wearable device
302
Recording and storing the subject inputs for "stress" and "craving" using subject buttons of the wearable device, in memory of the wearable device
304
Determining mean and variance of the training data stored in the memory of the wearable device
306
Performing signal processing such as transforming the 3-dimensional motion data into amplitude data using a microcontroller in the wearable device
308
Creating a training data histogram of the transformed data
310
Fitting a curve fit to the histogram data
312
Determining shape and scale of the curve fit
314
Applying machine learning to the mean, variance, shape and scale data to establish training set classification rules for stress and cravings reported by the subject using buttons
316
Transmitting the classified data to a cloud in order to build a deep neural network for further learning
318

FIG. 7

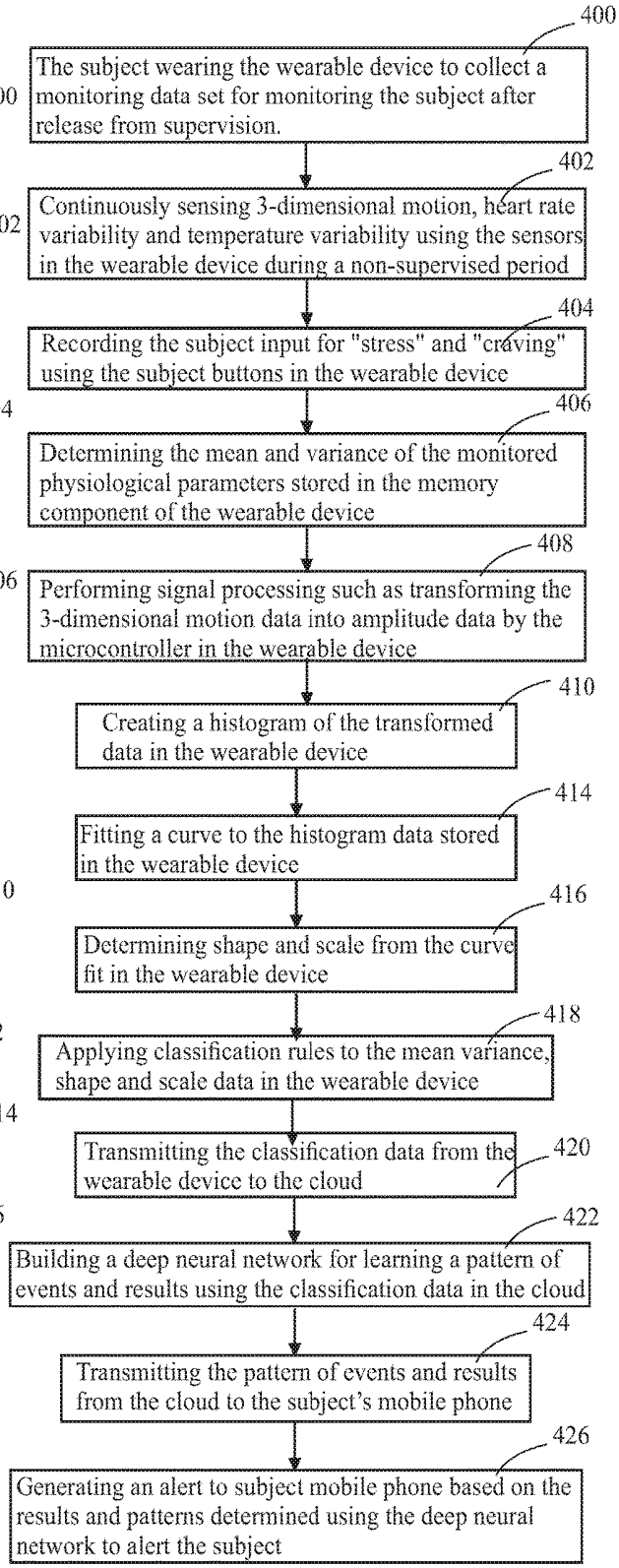

The subject wearing the wearable device to collect a monitoring data set for monitoring the subject after release from supervision.
400
Continuously sensing 3-dimensional motion, heart rate variability and temperature variability using the sensors in the wearable device during a non-supervised period
402
Recording the subject input for "stress" and "craving" using the subject buttons in the wearable device
404
Determining the mean and variance of the monitored physiological parameters stored in the memory component of the wearable device
406
Performing signal processing such as transforming the 3-dimensional motion data into amplitude data by the microcontroller in the wearable device
408
Creating a histogram of the transformed data in the wearable device
410
Fitting a curve to the histogram data stored in the wearable device
414
Determining shape and scale from the curve fit in the wearable device
416
Applying classification rules to the mean variance, shape and scale data in the wearable device
418
Transmitting the classification data from the wearable device to the cloud
420
Building a deep neural network for learning a pattern of events and results using the classification data in the cloud
422
Transmitting the pattern of events and results from the cloud to the subject's mobile phone
424
Generating an alert to subject mobile phone based on the results and patterns determined using the deep neural network to alert the subject
426

FIG. 8

EDGE-INTELLIGENT IOT-BASED WEARABLE DEVICE FOR DETECTION OF CRAVINGS IN INDIVIDUALS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a Continuation In Part of U.S. patent application Ser. No. 15/681,111 filed Aug. 18, 2017, which application is incorporated in its entirety herein by reference.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to addressing destructive cravings and in particular to a wearable device for monitoring a level of cravings experienced by a subject.

[0003] Drug addiction is an increasingly serious individual and societal issue. The rate of drug addiction in the United States has reached levels where this addiction affects not only the addict, but society as a whole. Many addicts recognize their personal damage due to the use of drugs and desire to overcome their addiction through various programs. The individuals often successfully complete a program, but are not able to remain drug free after re-entering society, especially when they are subject to the stress that both existed in the past, and stress produced by social issues they encounter when they attempt to rejoin society. Such stress often results in cravings to resume drug use. Other similar conditions include eating disorders/food addiction, co-occurring disorders with addiction, and Post-Traumatic Stress Disorder (PTSD). A need exists for identifying the presence of stress and the resulting cravings to allow intervention before a return to drug use.

[0004] Further, known commercially available wearable sensors only monitor an individual's heart rate and activity and may not provide sufficient measurements to support detection of stress likely to cause cravings.

BRIEF SUMMARY OF THE INVENTION

[0005] The present invention addresses the above and other needs by providing a wearable craving and drug use sensor suit. With the growth of interrelated systems of computing devices, mechanical and digital machines, objects, animals or people connected by the Internet, there is a significant interest in the use of wearable sensors such as smart watches and cell phones. These wearable sensors may be used to monitor physiological signals and provide health information. An edge-intelligent Internet based wearable assists in substance-abuse detection by monitoring an individual's physiological signals on a daily basis. The edge intelligent approach enables us to do all the processing of signals as well as assessment of the underlying condition in the device itself. The wearable device helps in monitoring cravings and substance abuse of the individual and help the healthcare provider to start an early intervention as required. The proposed system is developed as a dedicated substance abuse wearable system with commercially available off-the shelf components. An example of a wearable device is a medical quality wearable which yielded a correlation of 0.89 for accelerometer measurements and 0.92 for average heart rate values in tests

[0006] In accordance with another aspect of the invention, there is provided a system to detect an individual subject's stress, cravings, and use of drugs, based on physiological sensors, advanced signal processing and a machine learning framework. A wearable sensor suit is worn by a subject recovering from drug use. The sensor suit produces signals by measuring physiological parameters such as one, two, or three dimensions of body movement (locomotor activity), Electro Dermal Response (EDR), heart rate, skin temperature, a galvanic skin response. Statistical data (e.g., the mean and variance) of the measurements are computed. The statistical features may be used to assess cravings and/or stress in the individual subject. Data has shown that accelerometer measurements in each dimension are significantly but not perfectly (less than 100%) correlated with other dimensions, and hence the detection of stress and cravings can be achieved with one dimension data with reasonable accuracy without EDR or temperature data. The physiological data is processed in windows having a length L, for example, a five minute window.

[0007] In accordance with still another aspect of the invention, there is provided a system to determine shape and scale parameters of a distribution of amplitudes of the three dimensional movement data are computed. Amplitudes, frequencies, and phases of the three dimensions of motion signals may be obtained using an appropriate transform. The distribution of amplitudes provides a sensitive measure capable of detecting the frequency of use of drugs (heavy use vs. moderate use). Dynamic features such as instantaneous fluctuations of amplitudes, frequencies, and phases at multiple time scales may be obtained by the time-frequency decomposition of these signals using an appropriate transform, for example the Hilbert or a wavelet transform approach

[0008] In accordance with yet another aspect of the invention, there is provided a method for adapting a drug use risk detection method to an individual subject prior to release from a treatment facility. A training data set comprising statistical and dynamic features is collected and incorporated in a machine learning framework. The data is collected over a one to two day period where the individual is monitored to ensure that there is no drug use. The processed three dimensional motion signals, the EDR, and temperature signals, are processed by machine learning algorithms to establish boundaries for non-drug use. The machine learning framework is tailored specifically to individual subjects to assess pathological fluctuations in the physiological signals that can be used later assess the risk or return to drug use.

[0009] In accordance with another aspect of the invention, there is provided a method for detection of cravings. Following release of the individual subject from a treatment facility, the individual subject is provided with a wearable device measuring physiological data. The wearable device continuously measures physiological signals, and the signals are processed for relevant features related to cravings. An alert is provided to the individual subject and/or a provider through of any imminent risk of using illicit drugs or cravings. By accurately tracking the statistical and dynamic fluctuations in these physiological signals in real time, the method can provide accurate detection of cravings.

[0010] In accordance with yet another aspect of the invention, there is provided a method for providing alerts to a care giver. The present system includes non-invasive wearable biosensors that stream data continuously in real time to a processor which processes the physiological signals and executes a craving or risk detection software. Once a specific

threshold of risk has reached, the algorithm can trigger an alert through a cell phone to a user or a care giver or a provider.

[0011] In accordance with still another aspect of the invention, there is provided a method for providing alerts based on a 16 dimension vector space of ten physiological signals comprising mean and variance of three dimensional motion, EDR, and temperature, and six spatial features comprising shape and scale of histogram data.

[0012] In accordance with another aspect of the invention, there is provided a wearable sensor monitoring three dimensional data at a 32 samples per second, EDR data at four samples per second, and temperature data at one sample per second. The data is provided in windows of about 5 minute length.

[0013] In accordance with still another aspect of the invention, there is provided a monitoring system including a wearable sensor, a cell phone type device, and a monitoring facility. Data collected by the wearable sensor may be processed in the wearable sensor, in the cell phone type device, or at the monitoring facility. In some embodiments, the wearable sensor and cell phone type device may be a single device.

[0014] In accordance with another aspect of the invention, there is provided a wearable sensor. The wearable sensor includes physiological sensors and is an edge-intelligent device processing sensor measurements and sending assessments of cravings to a remote sever accessed by clinicians.

[0015] In accordance with yet another aspect of the invention, there is provided a method for a wearable sensor sensing and processing subject data during supervision. The method includes collecting training data, processing the training data, applying machine learning to the training data and subject inputs to determine classification rules, and transmitting the training rules to a cloud/clinicians.

[0016] In accordance with still another aspect of the invention, there is provided a method for a wearable sensor sensing and processing subject data after release from supervision. The method includes repeating the method used during supervision, but also building a deep neural network in the cloud or at clinician facilities, and providing alters to the subjects cell phone.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

[0017] The above and other aspects, features and advantages of the present invention will be more apparent from the following more particular description thereof, presented in conjunction with the following drawings wherein:

[0018] FIG. **1** shows components of a system for sensing physiological parameters and detecting cravings based on the physiological parameters in individuals with addiction according to the present invention.

[0019] FIG. **2** shows a method for processing the individual physiological parameters to detected cravings according to the present invention.

[0020] FIG. **3** shows a method for processing the individual physiological parameters measured during an unsupervised period to detect stress, cravings, and drug use.

[0021] FIG. **4** shows a plot of a training spectrum, a monitoring spectrum, and a threshold.

[0022] FIG. **5** is a wearable sensor according to the present invention.

[0023] FIG. **6** shows components of a wearable system for sensing physiological parameters and detecting cravings based on the physiological parameters in individuals with addiction according to the present invention.

[0024] FIG. **7** shows a method for collecting and processing a subject's physiological parameters during supervision.

[0025] FIG. **8** shows a method for collecting and processing a subject's physiological parameters after supervision and providing alerts.

[0026] Corresponding reference characters indicate corresponding components throughout the several views of the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0027] The following description is of the best mode presently contemplated for carrying out the invention. This description is not to be taken in a limiting sense, but is made merely for the purpose of describing one or more preferred embodiments of the invention. The scope of the invention should be determined with reference to the claims.

[0028] Where the terms "about" or "generally" are associated with an element of the invention, it is intended to describe a feature's appearance to the human eye or human perception, and not a precise measurement.

[0029] Components of a system for detection of cravings in individuals with addiction according to the present invention are shown in FIG. **1**. The system includes wearable devices **10** comprising sensor suit **20** and a cell phone type device **24** carried by the individual. The sensor suit **20** measures physiological parameters including three dimensional body movement, Electro Dermal Response (EDR), and temperature. A suitable sensor suit is described in US Patent Application Publication No. 2014/0316229 for "Apparatus for Electrodermal Activity Measurement with Current Compensation" filed 17 Mar. 2014. The sensor suit **20** includes at least one accelerometer, a temperature sensor, and EDR sensor. The '229 publication is incorporated by reference in its entirety into the present specification.

[0030] The sensor suit **20** preferably wirelessly communicates with a cell phone type device **24** to provide data **22** to the cell phone type device **24**. The wireless communication may be, for example, Bluetooth communication. While Bluetooth is a preferred wireless interface, those skilled in the art will recognize other types of communication, including wired, and a system according to the present including any form of communication between the sensors and the cell phone type device, and the sensor suit **20** and cell phone type device **24** may be a single device.

[0031] The cell phone type device **24** receives the three dimensional movement, the EDR, and temperature signals **22** from the sensor suit **20** and transits the data **26** to a stress monitoring center **30**. If the cravings exceed a threshold, or advanced processing indicates a craving, the stress monitoring center **30** may provide alerts **32***a* back to the subject and alerts **32***b* to support personnel. The data may be processed in the sensor suit **20**, the cell phone type device **24**, or at the stress monitoring center **30**, and the processing may be distributed over the sensor suit **20**, the cell phone type device **24**, and the stress monitoring center **30**. Those skilled in the art will recognize that any distribution of the method between devices is intended to come within the scope of the present invention.

[0032] A method for processing the individual physiological parameters measured during a period of supervised no drug use to establish classification rules is shown in FIG. **2**. The method includes wearing a sensor device to collect a training data set for supervised learning at step **100**, sensing 3 dimensional motion, Electro Dermal Response (EDR), and temperature training data over a one to two day period of supervised no drug use by the subject at step **102**, determining the mean and variance of the training data at step **104**, transforming the 3 dimensional motion training data into amplitude data at step **106**, creating a histogram of the transformed data at step **108**, fitting a curve to the histogram data at step **110**, determining shape and scale from the curve fit at step **112**, applying machine learning to the mean variance, shape and scale data to establish classification rules at step **114**. Examples of transforms used in steps **106** and **206** are a Hilbert transform or a wavelet transform. Examples of curves applied to the curve fit of steps **110** and **210** are fitting a gamma function to the amplitude data.

[0033] A method for processing the individual physiological parameters measured during an unsupervised period to detect stress, cravings, and drug use, is shown in FIG. **3**. The method includes wearing the sensor device to collect monitoring data set for the monitored subject after release from supervision at step **200**, continuously sensing monitored three dimensional motion, EDR, and temperature of the subject during a non-supervised period is shown in step **202**, determining the mean and variance of the monitored data is shown in step **204**, transforming the three dimensional motion monitored data into amplitude data is shown in step **206**, creating a histogram of the transformed data is shown in step **208**, fitting a curve to the histogram data is shown in step **210**, determining shape and scale from the curve fit is shown in step **212**, applying classification rules to the mean variance, shape and scale data is shown in step **214**, and generating an alert based on the results is shown in step **216**. The alerts may be provided to the subject and/or to a monitor and may be an alert for stress, for cravings, or of drug use.

[0034] A plot of a training spectrum, a monitoring spectrum, and a threshold are shown in FIG. **4**.

[0035] A wearable device **40** is shown in FIG. **5** and elements of a cravings/stress monitoring system **60** are shown in FIG. **6**. The wearable device **40** includes housing **41** including a 3-axis accelerometer sensor **48**, a thermopile sensor **50**, a pulse oximeter sensor **46**, a subject stress input (e.g., subject button) **42**, a subject craving input (e.g. subject button) **44**, and a microcontroller (e.g., microprocessor) **63**. The wearable device **40** collects processes physiological parameters and subject inputs to anticipate substance abuse by monitoring for the physiological parameters associated with stress leading to craving and detects substance abuse by monitoring for physiological parameters associated with substance abuse. The system **60** includes the wearable device **40** coupled to a clinician and/or cloud **66** and the subject's cell phone **70** over the Internet **64**. The wearable device **40** and/or the clinician and/or cloud **66** sends alerts **72** to the subject thoug h the internet **64** to the cell phone **68** to alert the subject to the onset of physiological conditions which may lead to harmful behavior, and the wearable device **40** sends messages **68** to the clinician/cloud **66** indicating a pattern of substance abuse and craving in the subject and for learning.

[0036] The thermopile sensor **50** detects temperature variability of the individual in given period of time. As a result, the temperature values are scheduled in such a way that the current temperature value is being compared with the previous acquired value constantly to check for the rate of change and corresponding variability. The 3-axis accelerometer sensor **48** monitors motion of the subject on daily basis. This motion may show that the subject has reported stress and craving in spite of maintaining an active lifestyle. The pulse oximeter sensor **46** is a medical grade sensor which measures the heart rate of the subject on daily basis. The subject stress and craving input **42** and **44** values indicate that the subject experience stress or cravings at an point of time. The subject inputs are recorded along with the timestamp at which the subject hits the inputs **42** or **44**.

[0037] Examples of features for detecting the cravings and substance abuse are gross body movement measured by the 3-axis accelerometer sensor **48**, temperature variability measured by the thermopile sensor **50**, and heart rate measured by the pulse oximeter sensor **46**. The subject may also input stress and craving which may be correlated with the sensor measurements to monitor substance abuse of the subject. For example, if the subject records stress or craving, the corresponding sensor measurements are labeled as "substance event", otherwise measurements are labeled as "normal event". If a similar set of sensor measurements are detected, but there is no subject input at a particular time instance, then they are marked for "vulnerable event". The clinician periodically reviews this set of sensor measurements to detect a pattern of substance abuse and craving in the subject. While a preferred sensor suit is shown in FIG. **5**, data collection has shown that cravings and drug use may be identified with as few as one of the sensors, and a system with at least one of the sensors in FIG. **5** is intended to come within the scope of the present invention.

[0038] An example of the purpose of obtaining the subject inputs at a given time instance is to mark the number of times the subject is stressed which might lead to substance craving. Hence the following subject input protocol is maintained to effectively derive at the proposed hypotheses based on subject input values: a simple questionnaire to mark the stress and anxiety levels of the subject before using the wearable is recorded; a preliminary assessment on the substance abuse of the subject before using the wearable is recorded; the subject is informed of their accountability in pressing the input buttons whenever they feel stressed or possess substance craving at any time of the day; and the subject is informed of subject rewards such as points that are given to the subject every time a pattern of healthy active lifestyle is detected, including regular exercise or providing reliable subject inputs on stress and cravings.

[0039] A method for collecting and processing a subject's physiological parameters during supervision is shown in FIG. **7**. The method includes: a subject wearing a wearable device including senors to collect a training data (physiological parameters) set for supervised learning at step **300**, sensing 3-dimensional motion, heart rate variability and temperature variability using the sensors in the wearable device over a one to two day period of no drug use, using the wearable device at step **302**, recording and storing the subject inputs for "stress" and "craving" using subject buttons of the wearable device, in memory of the wearable device at step **304**, determining mean and variance of the training data stored in the memory of the wearable device at step **306**, performing signal processing such as transforming the 3-dimensional motion data into amplitude data using a

microcontroller in the wearable device at step **308**, creating a training data histogram of the transformed data at step **310**, fitting a curve fit to the histogram data at step **312**, determining shape and scale of the curve fit at step **314**, applying machine learning to the mean, variance, shape and scale data to establish training set classification rules for stress and cravings reported by the subject using buttons at step **316**, and transmitting the classified data to a cloud in order to build a deep neural network for further learning at step **318**.

[0040] A method for collecting and processing a subject's physiological parameters after supervision and providing alerts, is shown in FIG. **8**. The method includes: the subject wearing the wearable device to collect a monitoring data set for monitoring the subject after release from supervision at step **400**, continuously sensing 3-dimensional motion, heart rate variability and temperature variability using the sensors in the wearable device during a non-supervised period at step **402**, recording the subject input for "stress" and "craving" using the subject buttons in the wearable device at step **404**, determining the mean and variance of the monitored physiological parameters stored in the memory component of the wearable device at step **406**, performing signal processing such as transforming the 3-dimensional motion data into amplitude data by the microcontroller in the wearable device at step **408**, creating a histogram of the transformed data in the wearable device at step **410**, fitting a curve to the histogram data stored in the wearable device at step **414**, determining shape and scale from the curve fit in the wearable device at step **416**, applying classification rules to the mean variance, shape and scale data in the wearable device at step **418**, transmitting the classification data from the wearable device to the cloud at step **420**, building a deep neural network for further learning using the classification data in the cloud at step **422**, transmitting a pattern of events and results from the cloud to the subject's mobile phone at step **424**, and generating an alert to a subject mobile phone based on the results and patterns determined using the deep neural network to alert the subject at step **426**.

[0041] The deep neural network processing in step **422** may alternatively be performed in the wearable device using an edge intelligent approach. In instances where insufficient data is available for the deep neural network processing, the cell phone alerts may be solely based on comparing non-supervised measurements to the classification rules.

[0042] While the methods of the present invention specifically target cravings for drugs, similar methods may be developed an applied to other disorders, for example, eating disorders/food addiction, co-occurring disorders with addiction, and Post-Traumatic Stress Disorder (PTSD). Those skill in the art will recognize that the methods of the present invention directed to these other disorders com e within the scope of the present invention.

[0043] While the invention herein disclosed has been described by means of specific embodiments and applications thereof, numerous modifications and variations could be made thereto by those skilled in the art without departing from the scope of the invention set forth in the claims.

I claim:

1. A wearable device for detecting craving of a subject, comprising:

a housing including:

at least one sensor selected from the group consisting of an accelerometer, a thermopile sensor, and a pulse oximeter sensor

at least one subject button selected from the group consisting a subject stress input button and a subject craving input button; and

a microprocessor electrically connected to the at least one sensor and the at least one subject button;

wireless communications between the microprocessor and at least one of a subject cell phone, a clinician, and a cloud,

wherein:

during a supervised period, the microprocessor processes signals from the at least one sensor and the at least one in put buttons to determine training set classification rules; and

during an unsupervised period:

the microprocessor processes signals from the at least one sensor to determine characteristics of the unsupervised sensor data; and

the microprocessor compares the characteristics of the unsupervised sensor data to the training set classification rules; and

at least one element selected from the group consisting of the microprocessor, the clinician, and the cloud, provides alerts to the subject cell phone based on the comparison.

2. The wearable device of claim **1**, wherein:

the microprocessor transmits classification data from the wearable device to a remote site during the unsupervised period;

at the remote site, the classification data is processed using a deep neural network to refine the training set classification rules; and

the remote site provides alerts to the subject cell phone based on the processed classification data.

3. The wearable device of claim **1**, wherein the remote site is a cloud.

4. The wearable device of claim **1**, wherein:

during the unsupervised period the microprocessor applies deep neural network processing to refine the classification rules; and

the microprocessor provides alerts to the subject cell phone based on the refined classification rules.

5. The wearable device of claim **1**, wherein:

processing the signals from the at least one sensor and the at least one input buttons to determine training set classification rules during the supervised period comprises:

producing training motion data in the at least one dimension by sensing the training motion of the subject during a period of no drug use;

generating training statistics of the training motion data during the period of no drug use; and

determining classification rules for the training statistics during the period of no drug use; and

processing signals from the at least one sensor to determine characteristics of the unsupervised sensor data comprises producing monitoring motion data in the at least one dimension by sensing monitoring motion of the subject during the period of non-supervision.

6. The method of claim **5**, wherein:

sensing the training motion comprises sensing training accelerometer data in at least one dimension; and

sensing monitoring motion comprises sensing monitoring accelerometer data in the at least one dimension.

7. The method of claim 6, wherein:
generating training statistics comprises computing training mean and training variance of the training accelerometer data and determining the classification rules of the training statistics comprises determining classification rules of the mean and the variance of the training mean and the training variance; and
generating monitoring statistics comprises computing monitoring mean and monitoring variance of the monitoring accelerometer data and comparing the monitoring statistics comprises comparing the monitoring mean and the monitoring variance to the classification rules.

8. The method of claim 7, further including:
collecting training Electrodermal Response (EDR) and training temperature data during the period of no drug use;
determining a training EDR mean and variance and a training temperature mean and variance;
including the training EDR mean and variance and the training temperature mean and variance in determining the classification rules;
collecting monitoring EDR and monitoring temperature data during the period of non-supervision;
determining monitoring EDR and monitoring temperature mean and variance from the monitoring EDR and the monitoring temperature data; and
including comparing the monitoring EDR mean and variance and monitoring temperature mean and variance to the classification rules to determine if the drug cravings are present.

9. The method of claim 8, wherein the training data and the monitoring data is collected and processed in windows having a length between three and seven minutes.

10. The method of claim 9, wherein the training data and the monitoring data is collected and processed in windows having a length of about five minutes.

11. The method of claim 8, wherein the at least one dimension comprises at least two dimensions.

12. The method of claim 8, wherein the at least one dimension comprises three dimensions.

13. The method of claim 6, wherein the at least one dimension comprises at least two dimensions, and further including:
determining the training mean and variance of the training motion data in the at least two dimensions;
transforming the training motion data into training amplitude data;
creating training histogram data from the training amplitude data;
fitting a training curve to the training amplitude data;
determining training shape and scale based on the training curve;
determining monitoring mean and variance of the monitoring motion data in the at least two dimensions;
transforming the monitoring motion data into monitoring amplitude data;
creating monitoring histogram data from the monitoring amplitude data;
fitting a monitoring curve to the monitoring amplitude data;
determining monitoring shape and scale based on the monitoring curve; and
including comparing the monitoring shape and scale parameters to the shape and scale classification rules to determine if the drug cravings are present.

14. The method of claim 13, wherein;
transforming the training motion data into training amplitude data comprises transforming the training motion data into training amplitude data using a Hilbert transform; and
transforming the monitoring motion data into monitoring amplitude data comprises transforming the monitoring motion data into monitoring amplitude data using a Hilbert transform.

15. The method of claim 13, wherein;
transforming the training motion data into training amplitude data comprises transforming the training motion data into training amplitude data using a wavelet transform; and
transforming the monitoring motion data into monitoring amplitude data comprises transforming the monitoring motion data into monitoring amplitude data using a wavelet transform.

16. The method of claim 13, wherein:
fitting a training curve to the training amplitude data comprises fitting a gamma function to the training amplitude data; and
fitting a monitoring curve to the monitoring amplitude data comprises fitting a gamma function to the training amplitude data.

17. The method of claim 7, wherein the at least one dimension comprises at least two dimensions, and further including:
determining training phase correlation between the at least two dimensions;
determining training classification rules further based on the training phase correlation;
determining monitoring phase correlation between the at least two dimensions;
including comparing the monitoring phase correlation to the classification rules to determine if the drug cravings are present.

18. A wearable device for detecting craving of a subject, comprising:
a housing including:
sensors comprising an accelerometer, a thermopile sensor, and a pulse oximeter sensor
subject buttons comprising a subject stress input button and a subject craving input button; and
a microprocessor electrically connected to the at least one sensor and the input buttons;
wireless communications between the microprocessor and at least one of a subject cell phone, a clinician, and a cloud,
wherein:
during a supervised period, the microprocessor processes signals from the sensors and the subject buttons to determ ine training set classification rules; and
during an unsupervised period:
the microprocessor processes signals from the sensors and the subject buttons to determ ine characteristics of the unsupervised sensor data;

the microprocessor compares the characteristics of the unsupervised sensor and the subject buttons data to the training set classification rules; and

alerts to the subject cell phone based on the com parison.

19. A wearable device for detecting craving of a subject, comprising:

a housing including:

sensors comprising an accelerometer, a thermopile sensor, and a pulse oximeter sensor

subject buttons comprising a subject stress input button and a subject craving input button; and

a microprocessor electrically connected to the at least one sensor and the input buttons;

wireless communications between the microprocessor and a cloud;

wireless communications between the cloud and a subject cell phone;

wherein:

during a supervised period, the microprocessor processes signals from the sensors and the subject buttons to determ ine training set classification rules; and

during an unsupervised period:

the microprocessor processes signals from the sensors and the subject buttons to determine characteristics of the unsupervised sensor data;

the microprocessor comparing the characteristics of the unsupervised sensor and the subject buttons data to the training set classification rules to determine classification data;

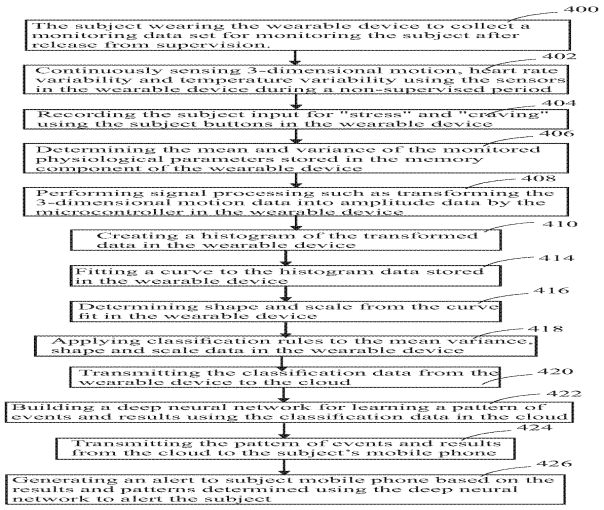
the microprocessor transmits the classification data to the cloud;

the cloud applies deep neutral network to determine a pattern of events and results from the classification data;

the cloud transmitting alerts to the subject cell phone based on the pattern of events and results.

* * * * *

专利名称(译)	基于边缘智能物联网的可穿戴设备，用于检测个人的渴望		
公开(公告)号	US20200085301A1	公开(公告)日	2020-03-19
申请号	US16/688861	申请日	2019-11-19
[标]申请(专利权)人(译)	INDIC PREMANANDA		
申请(专利权)人(译)	INDIC，PREMANANDA		
当前申请(专利权)人(译)	INDIC，PREMANANDA		
[标]发明人	REINHARDT MEGAN GILBERTSON NICOLE INDIC PREMANANDA		
发明人	REINHARDT, MEGAN GILBERTSON, NICOLE INDIC, PREMANANDA SUNDARAVADIVEL, PRABHA		
IPC分类号	A61B5/00 G06K19/077 A61B5/0205 G16H40/63 G06F1/16		
CPC分类号	G06F1/163 G06K19/07762 G16H40/63 A61B5/0205 A61B5/0022 A61B5/01 A61B5/0531 A61B5/11 A61B5/165 A61B5/6898 A61B5/7267 G16H40/67 G16H50/70		
外部链接	Espacenet USPTO		

摘要(译)

可穿戴生理监测系统包括可商购的现成组件。 随着通过互联网连接的计算设备，机械和数字机器，物体，动物或人的相互关联的系统的增长，人们对使用可穿戴式传感器（例如手机手表和手机）产生了极大的兴趣。 这些可穿戴传感器可用于监视生理信号并提供健康信息。 基于边缘智能互联网的可穿戴设备通过连续监视和解释个人的生理信号来帮助进行药物滥用检测。 可穿戴设备有助于监测个人的渴望和药物滥用，并帮助医疗保健提供者根据需要开始早期干预。 拟议的系统被开发为专用于滥用药物的可穿戴系统。 可穿戴设备的一个示例是医疗质量可穿戴设备，在测试中，加速度计测量的相关性为0.89，平均心率测量的相关性为0.92。