US 20200000337A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2020/0000337 A1**

DUCAO et al. (43) **Pub. Date: Jan. 2, 2020**

(54) **SYSTEM AND METHOD FOR BIOMETRIC-BASED SPATIAL CATEGORIZATION**

(71) Applicant: **DuKorp Corp.**, Brooklyn, NY (US)

(72) Inventors: **Arlene DUCAO**, Brooklyn, NY (US); **Ilias KOEN**, Athens (GR); **Christopher WILLARD**, Brooklyn, NY (US); **Yapah BERRY**, Jersey City, NJ (US)

(21) Appl. No.: **16/452,823**

(22) Filed: **Jun. 26, 2019**

Related U.S. Application Data

(60) Provisional application No. 62/692,789, filed on Jul. 1, 2018.

Publication Classification

(51) **Int. Cl.**

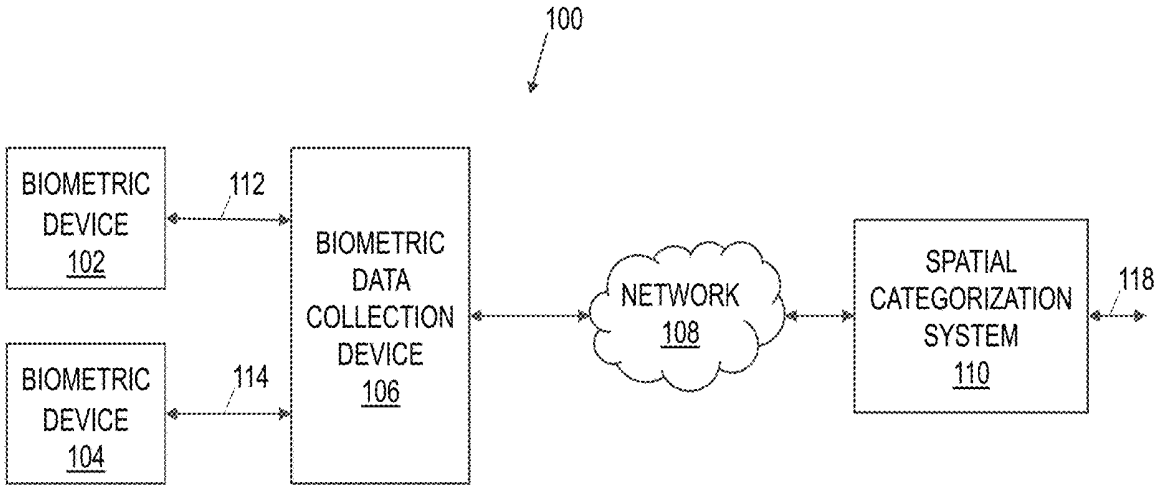
A61B 5/00	(2006.01)
A61B 5/0478	(2006.01)
A61B 5/024	(2006.01)
G06F 16/906	(2006.01)
G06F 16/909	(2006.01)
G06F 16/908	(2006.01)
H04W 4/029	(2006.01)

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

CPC ***A61B 5/0022*** (2013.01); ***A61B 5/0478*** (2013.01); ***A61B 5/02438*** (2013.01); ***H04W 4/029*** (2018.02); ***G06F 16/909*** (2019.01); ***G06F 16/908*** (2019.01); ***G06F 16/906*** (2019.01)

(57) **ABSTRACT**

A system includes a biometric device, a biometric data collection device, and a spatial categorization system. The biometric device includes a biometric sensor to measure a biometric trait of a user. The biometric data collection device includes a positioning system and a biometric data storage system, and a third wireless transceiver. The positioning system is configured to provide spatial location values specifying a geographic location of the biometric data collection device. The biometric data storage system is configured to assign time stamp values to each of the spatial location values and biometric trait measurements. The spatial categorization system is configured to identify a biometric trait measurement indicating that a condition of the user has a value that exceeds a threshold, and to assign, based on the identified biometric trait measurement, a category identification value to a spatial region corresponding to the spatial location value.



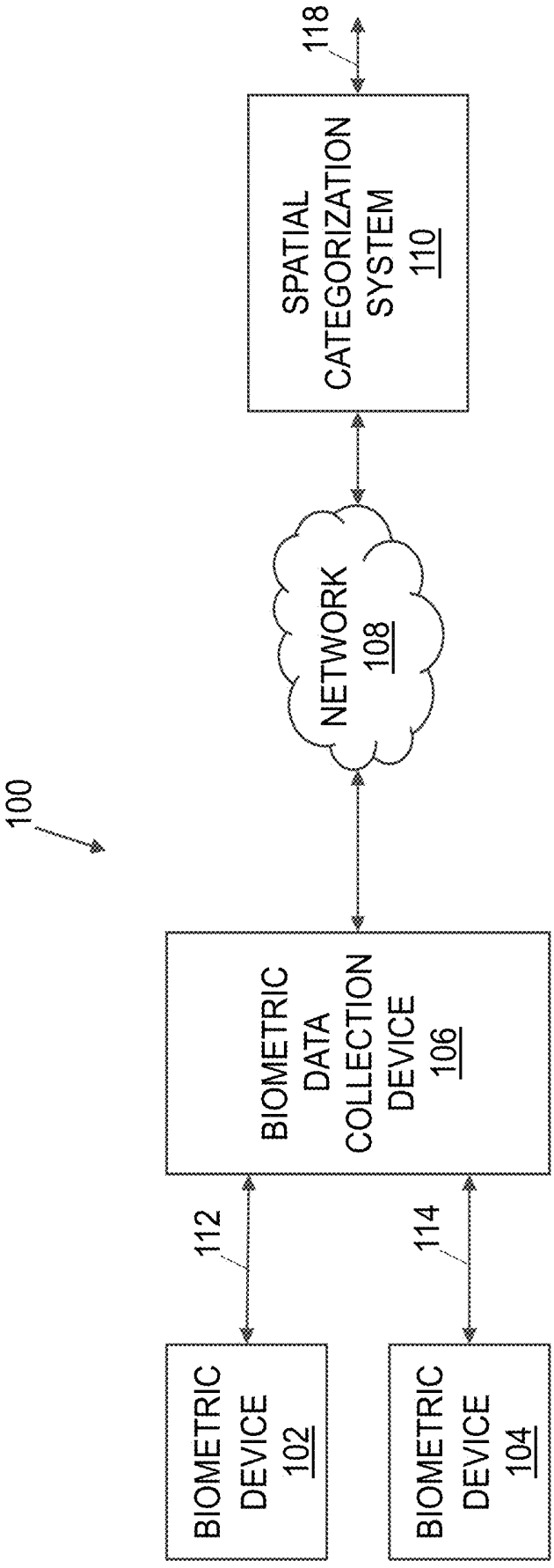

100
BIOMETRIC DEVICE 102
BIOMETRIC DEVICE 104
112
114
BIOMETRIC DATA COLLECTION DEVICE 106
NETWORK 108
SPATIAL CATEGORIZATION SYSTEM 110
118

FIG. 1

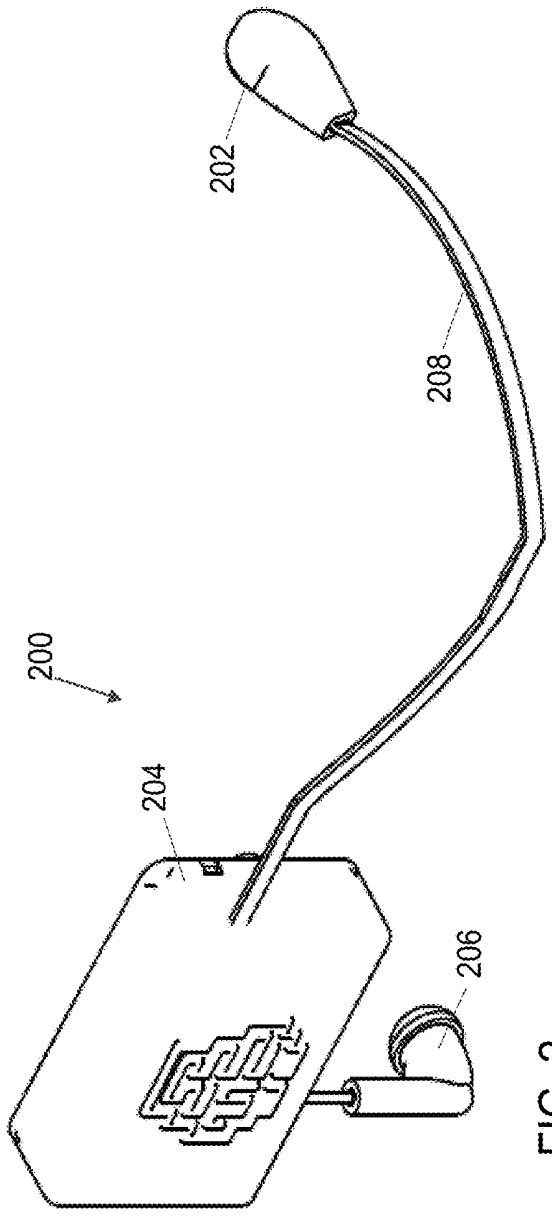


FIG. 2

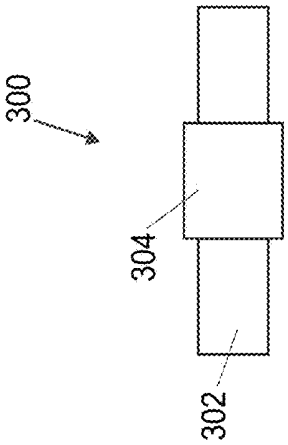


FIG. 3

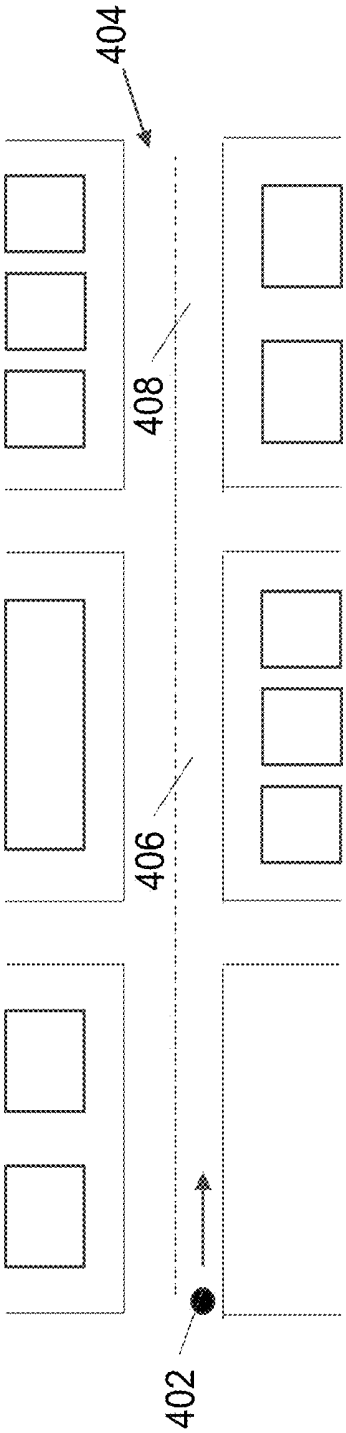


FIG. 4

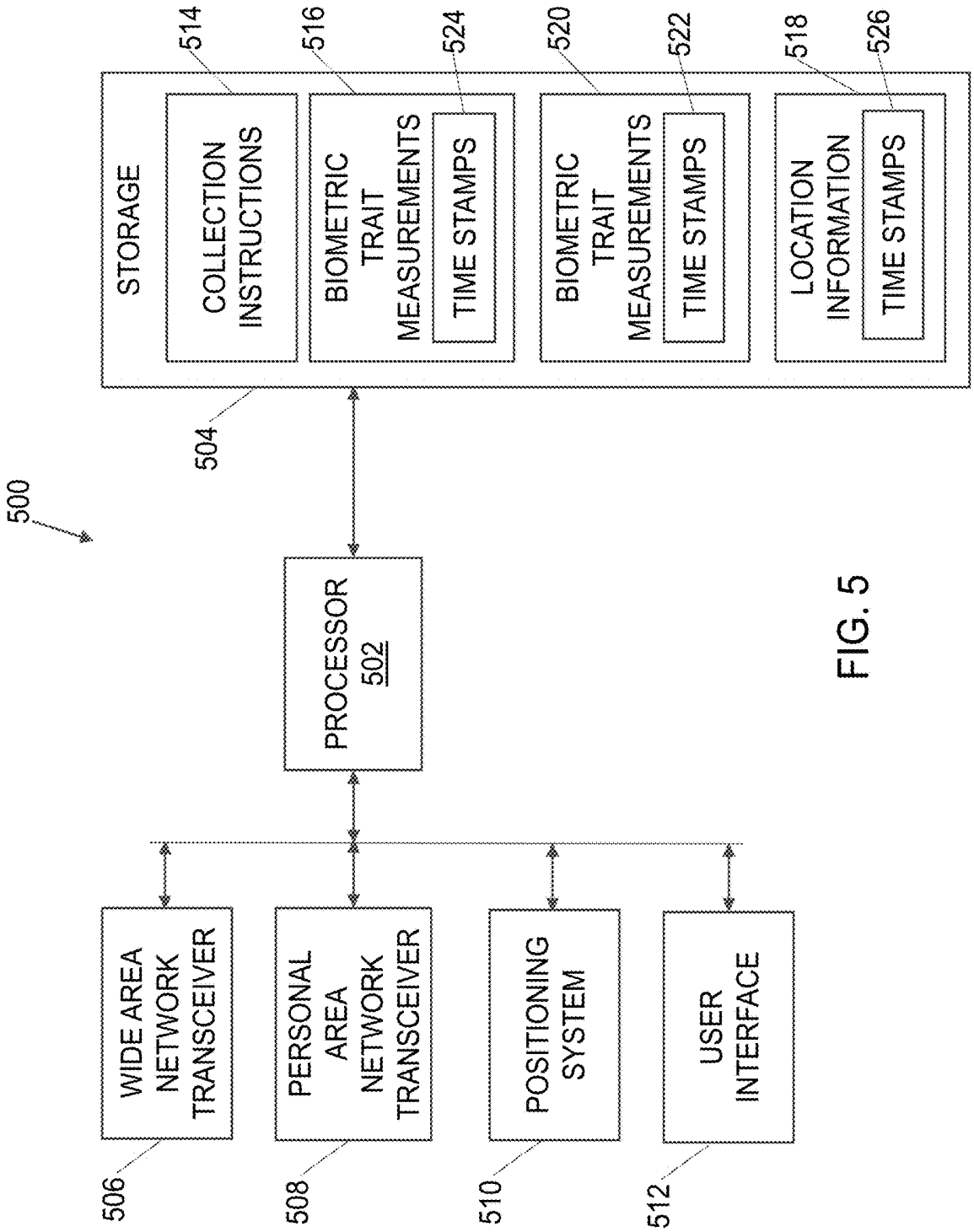

500
STORAGE
504
514
COLLECTION INSTRUCTIONS
516
BIOMETRIC TRAIT MEASUREMENTS
524
TIME STAMPS
520
BIOMETRIC TRAIT MEASUREMENTS
522
TIME STAMPS
518
LOCATION INFORMATION
526
TIME STAMPS
PROCESSOR 502
WIDE AREA NETWORK TRANSCEIVER
506
PERSONAL AREA NETWORK TRANSCEIVER
508
POSITIONING SYSTEM
510
USER INTERFACE
512

FIG. 5

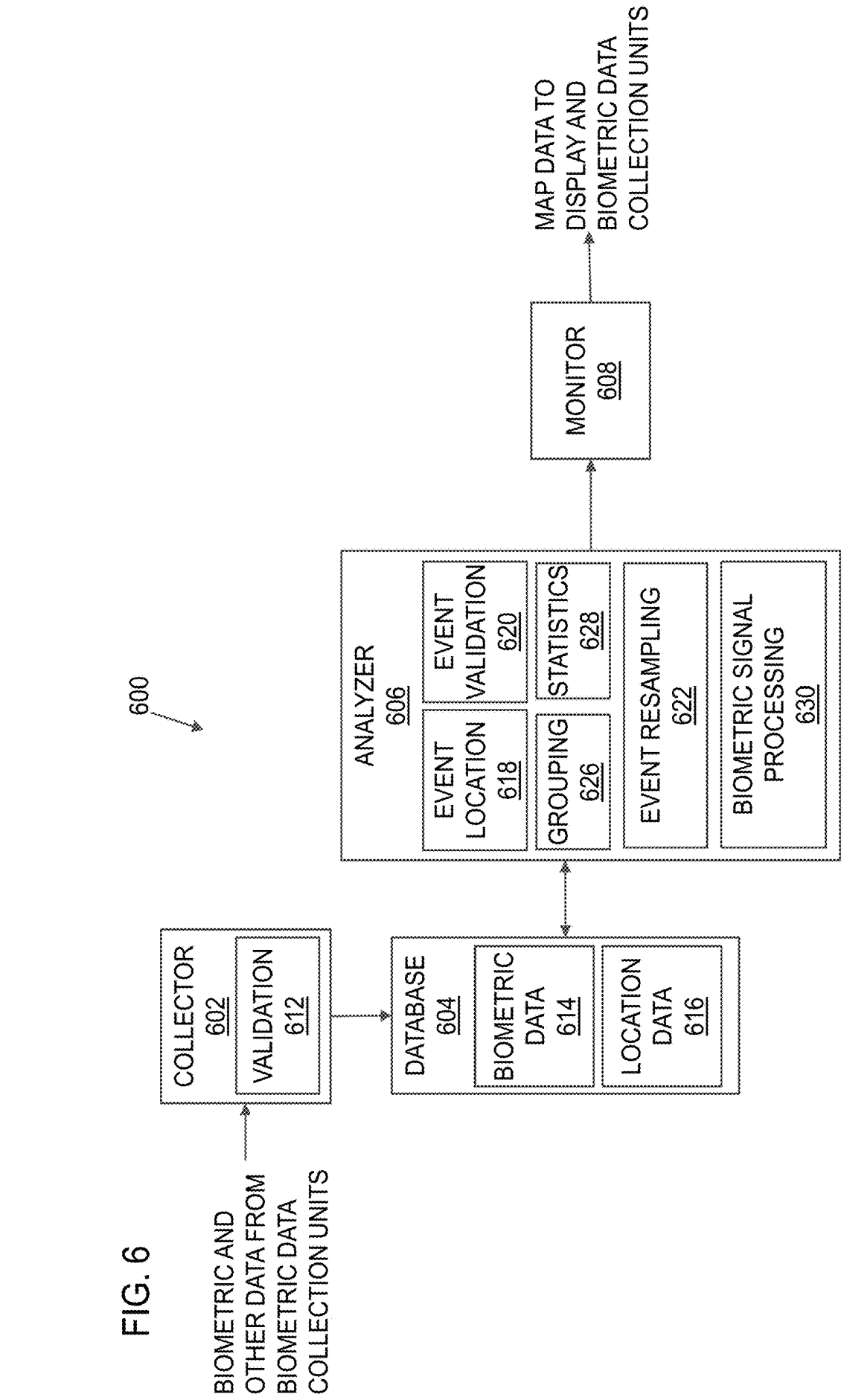

600
BIOMETRIC AND OTHER DATA FROM BIOMETRIC DATA COLLECTION UNITS
COLLECTOR 602
VALIDATION 612
DATABASE 604
BIOMETRIC DATA 614
LOCATION DATA 616
ANALYZER 606
EVENT LOCATION 618
EVENT VALIDATION 620
GROUPING 626
STATISTICS 628
EVENT RESAMPLING 622
BIOMETRIC SIGNAL PROCESSING 630
MONITOR 608
MAP DATA TO DISPLAY AND BIOMETRIC DATA COLLECTION UNITS

FIG. 6

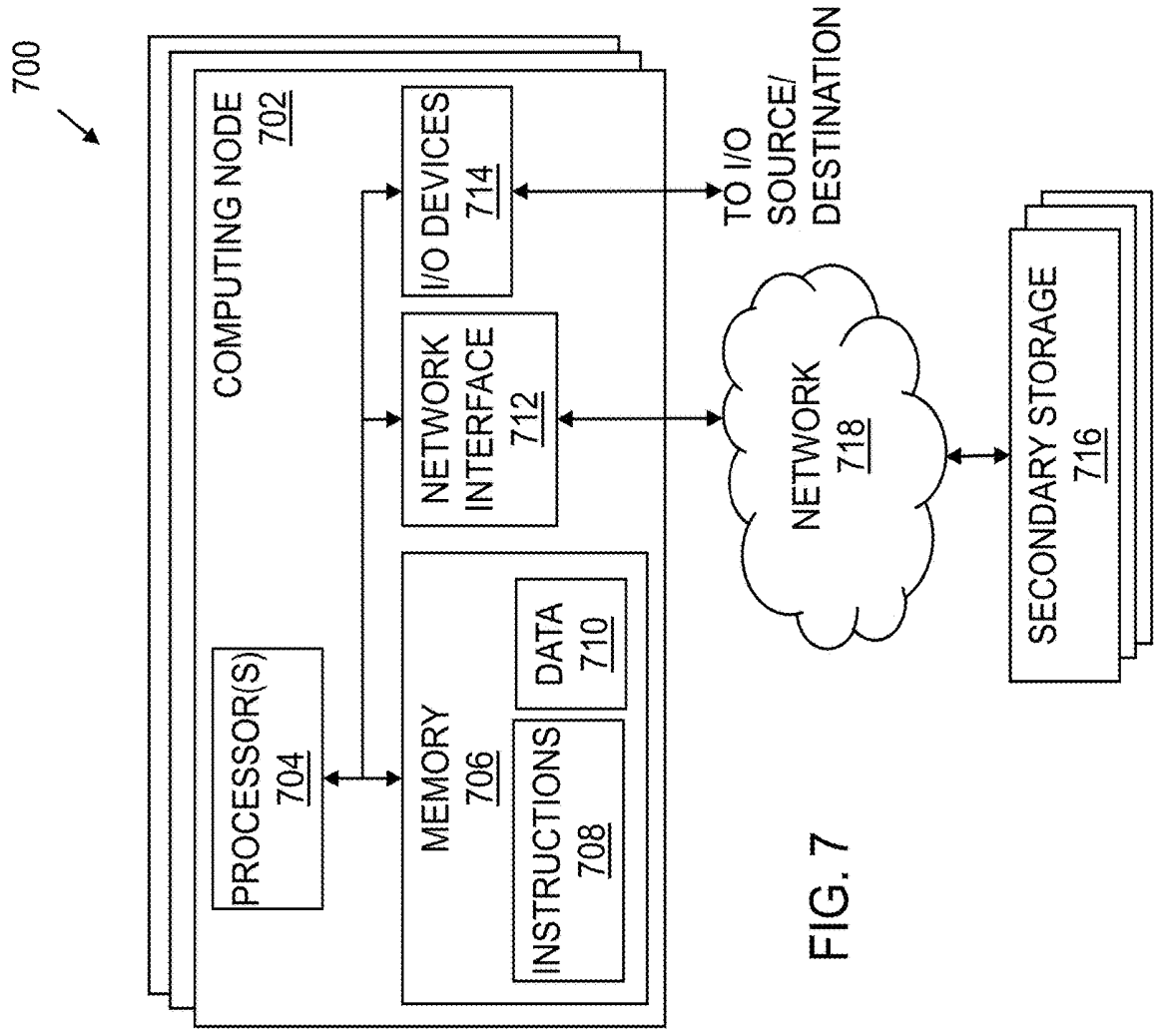

700
COMPUTING NODE
702
PROCESSOR(S)
704
MEMORY
706
INSTRUCTIONS
708
DATA
710
NETWORK INTERFACE
712
I/O DEVICES
714
TO I/O SOURCE/ DESTINATION
NETWORK
718
SECONDARY STORAGE
716

FIG. 7

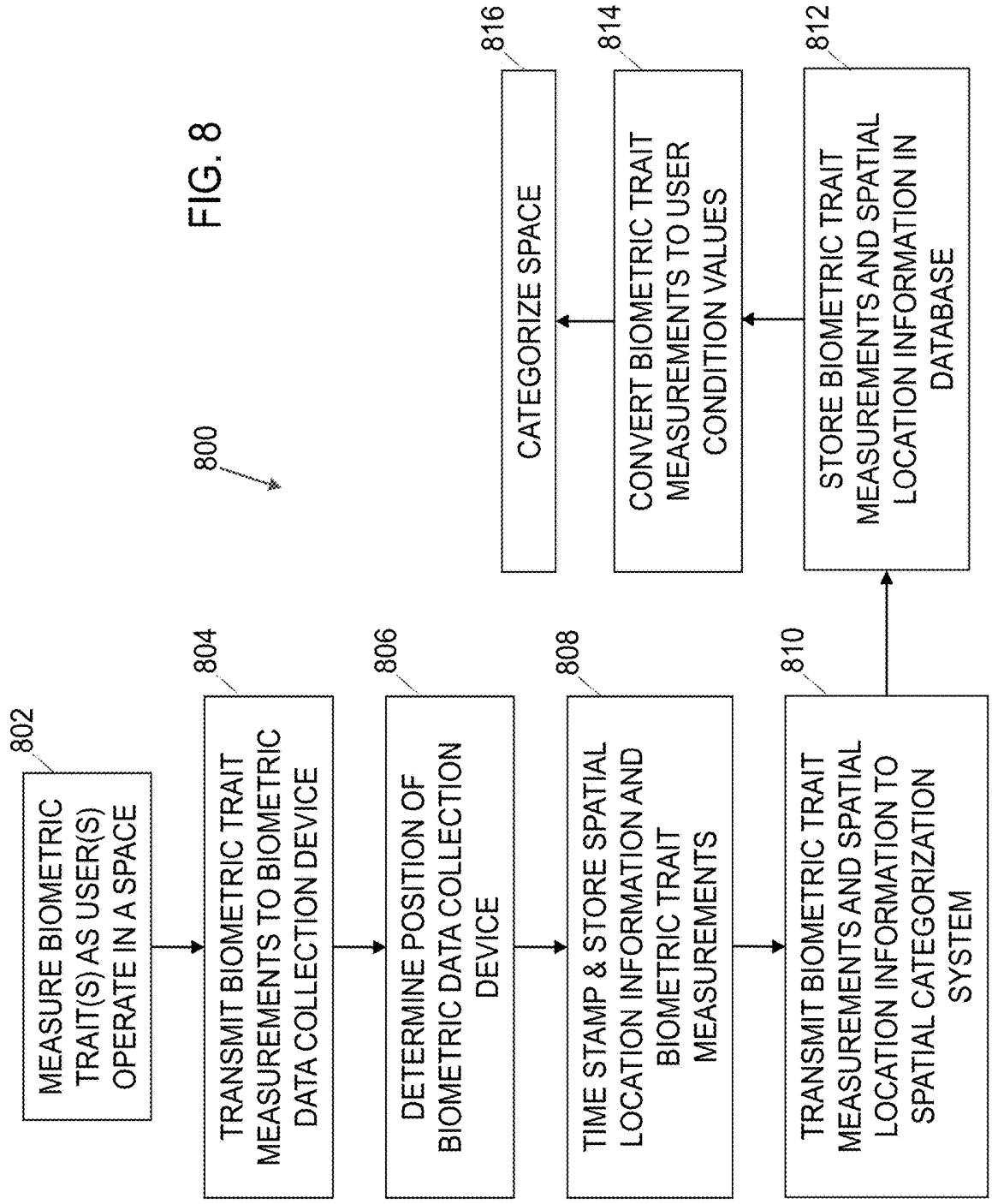

800
802
MEASURE BIOMETRIC TRAIT(S) AS USER(S) OPERATE IN A SPACE
804
TRANSMIT BIOMETRIC TRAIT MEASUREMENTS TO BIOMETRIC DATA COLLECTION DEVICE
806
DETERMINE POSITION OF BIOMETRIC DATA COLLECTION DEVICE
808
TIME STAMP & STORE SPATIAL LOCATION INFORMATION AND BIOMETRIC TRAIT MEASUREMENTS
810
TRANSMIT BIOMETRIC TRAIT MEASUREMENTS AND SPATIAL LOCATION INFORMATION TO SPATIAL CATEGORIZATION SYSTEM
812
STORE BIOMETRIC TRAIT MEASUREMENTS AND SPATIAL LOCATION INFORMATION IN DATABASE
814
CONVERT BIOMETRIC TRAIT MEASUREMENTS TO USER CONDITION VALUES
816
CATEGORIZE SPACE

FIG. 8

FIG. 9

SYSTEM AND METHOD FOR BIOMETRIC-BASED SPATIAL CATEGORIZATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority to U.S. Provisional Patent Application No. 62/692,789, filed Jul. 1, 2018, entitled "System and Method for Biometric-Based Spatial Categorization," which is hereby incorporated herein by reference in its entirety.

BACKGROUND

[0002] As biosensing technology has become cheaper and easier to use, biosensor use is increasing greatly. For example, biosensors available in wristband form factors are widely used to track electro-dermal activity, measure heart rate or heart rate variability, and other physiological traits. The biometric data produced by such sensors can be used in a wide range of applications including health and fitness tracking, stress monitoring, and entertainment.

SUMMARY

[0003] In one example, a system includes a biometric device, a biometric data collection device, and a spatial categorization system. The biometric device includes a biometric sensor, and a first wireless transceiver. The biometric sensor is configured to measure a biometric trait of a user. The first wireless transceiver circuit is configured to transmit biometric trait measurements. The biometric data collection device includes a second wireless transceiver circuit, a positioning system, a biometric data storage system, and a third wireless transceiver circuit. The second wireless transceiver circuit is configured to receive the biometric trait measurements transmitted by the biometric device. The positioning system is configured to provide spatial location values specifying a geographic location of the biometric data collection device. The biometric data storage system is configured to assign time stamp values to each of the biometric trait measurements, and each of the spatial location values. The biometric data storage system is also configured to store the biometric trait measurements, the spatial location values, and the assigned time stamp values. The third wireless transceiver circuit is configured to transmit the biometric trait measurements, the spatial location values, and the assigned time stamp values. The spatial categorization system is configured to receive the biometric trait measurements the spatial location values, and the assigned time stamp values, and to associate each of the biometric trait measurements with one of the spatial location values based on time stamp values. The spatial categorization system is also configured to identify a first of the biometric trait measurements indicating that a first condition of the user has a value that exceeds a first threshold, and to identify a second of the biometric trait measurements indicating that a second condition of the user has a value that exceeds a second threshold. The spatial categorization system is further configured to assign, based on the identified first of the biometric trait measurements, a first category identification value to a first spatial region corresponding to the spatial location value associated with the identified first of the biometric trait measurements, and to assign, based on the identified second of the biometric trait measurement, a second category identification value to a second spatial region corresponding to the spatial location value associated with the identified second of the biometric trait measurements.

[0004] In another example, a method includes measuring, by a first biometric sensing device, a first biometric trait of a user. A timestamp is assigned to each measurement of the first biometric trait. Measurements of the first biometric trait are transmitted to a biometric data collection device via a wireless personal area network. Spatial location values defining a spatial location of the biometric data collection device are determined by a positioning system of the biometric data collection device. A timestamp is assigned to each spatial location value. The measurements of the first biometric trait and the spatial location values are transmitted by the biometric data collection device to a spatial categorization system via a wide area network. A first of the measurements of the first biometric trait indicating that a first condition of the user has a value that exceeds a first threshold is identified by the spatial categorization system. A first category identification value is assigned, by the spatial categorization system, based on the first of the measurements of the first biometric trait, to a first spatial region corresponding to a spatial location value associated by the time stamps with the first of the measurements of the first biometric trait.

[0005] In a further example, a system includes an electroencephalography (EEG) device, a heart rate measurement device, a biometric data collection device, and a spatial categorization system. The EEG device includes an EEG sensor and first wireless transceiver. The EEG sensor is configured to measure electrical activity in a brain of a user. The first wireless transceiver circuit is configured to transmit EEG measurements. The heart rate measurement device includes a heart rate sensor and a second wireless transceiver circuit. The heart rate sensor is configured to measure heart rate of the user. The second wireless transceiver circuit is configured to transmit heart rate measurements. The biometric data collection device includes a third wireless transceiver circuit, a positioning system, a biometric data storage system, and a fourth wireless transceiver circuit. The third wireless transceiver circuit is configured to receive the EEG measurements and the heart rate measurements. The positioning system is configured to provide spatial location information specifying a geographic location of the biometric data collection device. The biometric data storage system is configured to assign time stamps to the spatial location information, the EEG measurements, and the heart rate measurements, and to store the EEG measurements, the heart rate measurements, and the spatial location information. The fourth wireless transceiver circuit is configured to transmit the EEG measurements, the heart rate measurements, and the spatial location information. The spatial categorization system is configured to receive the EEG measurements, the heart rate measurements, and the assigned spatial location information. The spatial categorization system is also configured to identify a first of the EEG measurements and a first of heart measurements indicating that a first condition of the user has a value that exceeds a first threshold, and identify a second of the EEG measurements and a second of the heart rate measurements indicating that a second condition of the user has a value that exceeds a second threshold. The spatial categorization system is further configured to assign, based on the first of the

EEG measurements and the first of heart rate measurements, a first category identification value to a first spatial region corresponding to the spatial location information associated by the time stamps with the first of the EEG measurements and the first of heart rate measurements, and to assign, based on the second of the EEG measurements and the second of ECG measurements, a second category identification value to a second spatial region corresponding to the spatial location information associated by the time stamps with the second of the EEG measurements and the second of heart rate measurements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] For a detailed description of various examples, reference will now be made to the accompanying drawings in which:

[0007] FIG. **1** shows a block diagram for a system that classifies space based on biometric data in accordance with the present disclosure;

[0008] FIG. **2** shows an example of a biometric device for acquiring electroencephalography data in accordance with the present disclosure;

[0009] FIG. **3** shows an example of a biometric device for acquiring electrocardiography data in accordance with the present disclosure;

[0010] FIG. **4** shows an example of acquisition of biometric data in a spatial environment in accordance with the present disclosure;

[0011] FIG. **5** shows a block diagram for an example of a biometric data collection device in accordance with the present disclosure;

[0012] FIG. **6** shows a block diagram for an example of a spatial categorization system in accordance with the present disclosure;

[0013] FIG. **7** shows a schematic diagram for a computing system suitable for implementation of a spatial categorization system in accordance with the present disclosure;

[0014] FIG. **8** show a flow diagram for a method for spatial categorization based on biometric trait measurements in accordance with the present disclosure; and

[0015] FIG. **9** shows an example of a map of a geographic area that includes spatial categorization based on biometric trait measurements in accordance with the present disclosure.

DETAILED DESCRIPTION

[0016] Certain terms have been used throughout this description and claims to refer to particular system components. As one skilled in the art will appreciate, different parties may refer to a component by different names. This document does not intend to distinguish between components that differ in name but not function. In this disclosure and claims, the terms "including" and "comprising" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to . . . ." Also, the term "couple" or "couples" is intended to mean either an indirect or direct wired or wireless connection. Thus, if a first device couples to a second device, that connection may be through a direct connection or through an indirect connection via other devices and connections. The recitation "based on" is intended to mean "based at least in part on." Therefore, if X is based on Y, X may be a function of Y and any number of other factors.

[0017] The systems and methods disclosed herein apply biometric data to categorize the spaces in which human beings operate. The systems of the present disclosure employ biometric sensors, such as electroencephalography (EEG) sensors and/or heart rate sensors (e.g., electrocardiography (ECG) sensors) to measure a user's response to space. The EEG and/or heart rate measurements may indicate how a space affects a user's state of mind. For example, the EEG and/or heart rate measurements may indicate whether a space tends to induce stress or relaxation in a user. Implementations may collect biometric data from any number of users and evaluate the biometric data acquired in a given space to categorize the given space.

[0018] Implementations of a biometric-based spatial categorization system include a biometric sensor, such as an EEG sensor or a heart rate sensor coupled to a user, and a biometric data collection device coupled to the biometric sensor. The biometric sensor measures a biometric trait of the user as the user operates in space. For example, an EEG sensor measures electrical brain activity of a user as the user traverses a geographic area. The biometric data collection device is communicatively coupled to the biometric sensor (e.g., by a personal area network, such as BLUETOOTH). The biometric sensor transmits measurements to the biometric data collection device. The biometric data collection device includes a positioning system (e.g., a global positioning system (GPS) receiver, or a local area network (LAN) positioning system) that provides spatial location information to identify the location at which each biometric value is performed. The biometric data collection device stores the biometric values and location information for transmission in bulk to a spatial categorization system.

[0019] The spatial categorization system includes a computing system (e.g., a virtual computing system) configured to analyze the biometric values and the spatial location information, and to categorize the spaces defined by the spatial location information based on the biometric values performed in the spatial area and received from one or more biometric data collection devices. For example, the categorization may include determining whether a level of stress induced by a space exceeds a threshold, determining whether a level of relaxation induced by space exceeds a threshold, and assigning a categorization value to the space based on biometric values relative to the thresholds. In some implementations, the categorization values assigned to spaces analyzed may be derived from a vocabulary used to describe a space in a particular context. The spatial categorizations produced by the system may be applied to reconfigure a space to elicit a desired biometric response from users. For example, a space may be configured to produce a higher level of relaxation in users.

[0020] FIG. **1** shows a block diagram for a system **100** that classifies space based on biometric data in accordance with the present disclosure. The system **100** includes a biometric device **102**, a biometric device **104**, a biometric data collection device **106**, and a spatial categorization system **110**. While the system **100** is illustrated as including two biometric devices (biometric device **102** and biometric device **104**), various implementations of the system **100** may include one or more biometric devices. The biometric device **102** and biometric device **104** measure one or more biometric traits of a user to which the biometric device **102** and/or biometric device **104** are attached. For example, the biometric device **102** may be EEG device that measures elec-

trical activity in a brain of a user, and the biometric device **104** may be a heart rate measurement device that measures heart rate or other cardiac activity of a user by electrical or optical sensing.

[0021] The biometric device **102** and the biometric device **104** are communicatively coupled to the biometric data collection device **106**. For example, the biometric device **102** and the biometric device **104** may be communicatively coupled to the biometric data collection device **106** via a personal area network, such as a BLUETOOTH wireless network. The biometric device **102** transfers measurements **112** of a biometric trait acquired by the biometric device **102** to the biometric data collection device **106** via the personal area network. Similarly, the biometric device **104** transfers measurements **114** of a biometric trait acquired by the biometric device **104** to the biometric data collection device **106** via the personal area network. The biometric data collection device **106** receives the measurements **112** and measurements **114**, and stores the measurements **112** and measurements **114** for transmission to the spatial categorization system **110**. The biometric trait measurements **112** and **114** may be stored as received from the biometric devices **102** or **104**, or in some implementations of the biometric data collection device **106** the biometric trait measurements **112** and **114** may be stored as values representing a range of values or a category into which each measurement falls. The biometric data collection device **106** includes a positioning system that provides information specifying the location of the biometric data collection device **106**. For example, the biometric data collection device **106** may include a global positioning system (GPS) receiver, or other satellite or terrestrial positioning system for determining the location of the biometric data collection device **106**. Some implementations of the biometric data collection device **106** may include a positioning system for determining the location of the biometric data collection device **106** within a structure, such as a building. For example, the biometric data collection device **106** may include a positioning system that determines the location of the biometric data collection device **106** based on signal strength of wireless LAN access points or other beacons disposed within a structure. The biometric data collection device **106** stores the location information in association with measurements **112** and biometric device **104** for transmission to the spatial categorization system **110**.

[0022] Some implementations of the biometric data collection device **106** allow a user to enter comments with regard to a space in which the user is operating to acquire the measurements **112** and measurements **114**. For example, the biometric data collection device **106** may allow the user to enter text describing the user's impressions of a space or information regarding conditions in the space that may have affected the measurements **112** and/or the measurements **114**. The biometric data collection device **106** stores such comments for transmission to the spatial categorization system **110** with the measurements **112**, the measurements **114**, and location information provided by the positioning system.

[0023] The biometric data collection device **106** transmits the measurements **112**, the measurements **114** (i.e., the biometric trait measurements), location information, user comments, etc. to the spatial categorization system **110** via the network **108**. The biometric trait measurements may be provided to the spatial categorization system as values received from the biometric devices **102** or **104**, or as values representing a range of values or a category into which each measurement falls. The network **108** may a wide area network, such as a cellular data communication network, the internet, etc.

[0024] The spatial categorization system **110** receives the biometric, location, and other information transmitted by the biometric data collection device **106** and analyzes the biometric data to classify or categorize the physical spaces in which the biometric data was acquired. For example, analysis of the measurements **112** and/or the measurements **114** may indicate that the user found a first space to be relaxing and found second space to be stressful. Thus, the spatial categorization system **110** may categorize a given space as relaxing or stressful based on the measurements **112** and/or the measurements **114** received from the biometric data collection device **106**. The spatial categorization system **110** may aggregate the measurements **112** and the measurements **114** with biometric trait measurements received from a plurality of different biometric data collection devices **106** associated with a plurality of different users to classify the various spaces of a geographic area. The spatial categorization system **110** may produce a map that illustrates the classification of spaces shown on the map based on the biometric trait measurements received from one or more instances of the biometric data collection device **106**. Such maps may be applied to change or reconfigure a space so as to change the experience of a user operating in the space. For example, if the spatial categorization system **110** classifies a space as stressful based on the measurements **112** and measurements **114**, then, responsive to the classification, the space may be reconfigured to reduce the stress associated with the space.

[0025] FIG. **2** shows an example of a biometric device **200** for acquiring EEG data in accordance with the present disclosure. The biometric device **200** may be an implementation of the biometric device **102**. The biometric device **200** includes an EEG electrode **202**, a reference electrode **206**, and circuitry **204**. The circuitry **204** is coupled to the EEG electrode **202** and the reference electrode **206**. The EEG electrode **202** is mounted to an arm **208** that positions the EEG electrode **202** for contact with a user's forehead. The reference electrode **206** captures non-brain electrical signals that provide a reference for the signals captured by the EEG electrode **202**. The reference electrode **206** may also provide a ground reference for the EEG electrode **202**. In some implementations, the reference electrode **206** may be configured for attachment to an ear or the user. The circuitry **204** includes circuitry to digitize signals detected by the EEG electrode **202**, and a transceiver to communicate with the biometric data collection device **106** via a personal area network. For example, the circuitry **204** may include an analog-to-digital converter and signal conditioning circuitry to process EEG signals, and a BLUETOOTH transceiver to communicate EEG signals detected by the EEG electrode **202** to the biometric data collection device **106**. The biometric device **200** also includes additional circuits and components, such as batteries and power supplies.

[0026] FIG. **3** shows an example of a biometric device **300** for acquiring cardiac data in accordance with the present disclosure. The biometric device **300** may be an implementation of the biometric device **104**. The biometric device **300** includes a band **302** and a cardiac sensor **304**. The band **302** may be, for example, a chest band or a wrist band. The

cardiac sensor **304** may include an ECG electrode to measure cardiac electrical signals, or an optical electrode to measure blood flow, from which heart rate and/or changes in heart rate can be determined. The cardiac sensor **304** also includes a transceiver to communicate with the biometric data collection device **106** via a personal area network. For example, the cardiac sensor **304** may include a BLUETOOTH transceiver to communicate cardiac signals to the biometric data collection device **106**. The biometric device **300** also includes additional circuits and components, such as batteries and power supplies.

[0027] FIG. **4** shows an example of acquisition of biometric data in a spatial environment in accordance with the present disclosure. In FIG. **4**, a user **402** is outfitted with a biometric device **200** and/or a biometric device **300**, and a biometric data collection device **106** that collects biometric data from the biometric device **200** and/or biometric device **300**, acquires location information, and generates time of acquisition information (i.e., timestamps). As the user **402** moves along the street **404**, on foot, on a bicycle, or in/on a motor vehicle, the biometric device **200** and/or the biometric device **300** measure a biometric trait (e.g., electrical brain activity, heart rate, etc.) of the user **402**. For example, the biometric device **200** and the biometric device **300** may measure the electrical brain signals and heart rate of the user **402** one or more times per second (e.g., measure EEG activity **512** times per second). As the user **402** moves along the street **404**, the environment around the user **402** produces changes in the user **402** that are reflected in the biometric data. For example, heavy traffic or other conditions in space **406** may result in increased stress in the user **402** that is reflected in the biometric data, while conditions in space **408** may produce increased relaxation in the user **402**. The biometric data transferred from the biometric device **200** and the biometric device **300** to the biometric data collection device **106** as the user **402** moves along the street **404** is transmitted to the spatial categorization system **110** for aggregation and analysis either automatically or at a time selected by the user **402**.

[0028] FIG. **5** shows a block diagram for an example of a biometric data collection device **500** in accordance with the present disclosure. The biometric data collection device **500** is an implementation of the biometric data collection device **106**. The biometric data collection device **500** includes a processor **502**, storage **504**, a wide area network transceiver **506**, a personal area network transceiver **508**, a positioning system **510**, and user interface circuitry **512**. The processor **502** may be a general-purpose microprocessor or a microcontroller that executes instructions retrieved from the storage **504** to perform the functions disclosed herein.

[0029] The wide area network transceiver **506** includes circuitry that allows the biometric data collection device **500** to access a wide area network and communicate with other devices and systems via the wide area network. For example, the wide area network transceiver **506** may include receiver circuitry and transmitter circuitry that enable communication via a cellular data network (e.g., an LTE network). The biometric data collection device **500** applies the wide area network transceiver **506** to communicate with the spatial categorization system **110**.

[0030] The personal area network transceiver **508** includes circuitry that allows the biometric data collection device **500** to access a personal area network and communicate with other devices and systems via the personal area network. For example, the personal area network transceiver **508** may include receiver circuitry and transmitter circuitry that enable communication via a BLUETOOTH network. The biometric data collection device **500** applies the personal area network transceiver **508** to communicate with the biometric device **102** and/or the biometric device **104**.

[0031] The positioning system **510** includes circuitry that determines the spatial location of the biometric data collection device **500**. For example, the positioning system **510** may include a GPS receiver, a GLONASS receiver, or other receiver for receiving signals from a satellite or terrestrial positioning system transmitter. In implementations of the biometric data collection device **500** that support positioning within a structure, such as a building, the positioning system **510** may include circuitry to determine the location of the biometric data collection device **500** based on LAN access point signal, beacon signal, dead reckoning, or other suitable interior positioning technology. For example, an implementation of the positioning system **510** may include a GPS receiver and LAN based positioning.

[0032] The user interface circuitry **512** includes circuitry that allows a user to interact with the biometric data collection device **500**. For example, the user interface circuitry **512** may include display circuitry, such liquid crystal display (LCD) circuitry, organic light emitting diode (OLED) display circuitry, etc. for presenting information to the user. The user interface circuitry **512** may include input circuitry, such as capacitive touch screen circuitry to allow the user to enter data into and control the biometric data collection device **500**.

[0033] The storage **504** is a non-transitory computer-readable medium that stores instructions executed by the processor **502** and data processed by the processor **502**. The storage **504** may include non-volatile storage, such as read-only memory, FLASH memory, etc., and volatile memory, such as dynamic random-access memory (DRAM), static random-access memory (SRAM), etc. The storage **504** includes collection instructions **514** that are executed by the processor **502** to process biometric trait measurements **516** and biometric trait measurements **520** received from the biometric device **200** and/or biometric device **300**. Such processing may include assigning time stamps **524** to the biometric trait measurements **516**, and assigning time stamps **522** to the biometric trait measurements **520**. The biometric trait measurements **516** and **520** with associated time stamps **524** and **522** are stored in the storage **504**, and transmitted to the spatial categorization system **110** via the wide area network transceiver **506**.

[0034] The storage **504** also stores the location information **518**. The location information **518** is provided by the positioning system **510**, and specifies the location of the biometric data collection device **500** when the biometric trait measurements **516** and/or the biometric trait measurements **520** were acquired. The processor **502** retrieves the location information **518** from the storage **504** for transmission to the spatial categorization system **110** via the wide area network transceiver **506**.

[0035] Other information, such as comments entered by the user, may also be stored in the storage **504**, and retrieved therefrom for transmission to the spatial categorization system **110** via the wide area network transceiver **506**.

[0036] FIG. **6** shows a block diagram for an example of a spatial categorization system **600** in accordance with the present disclosure. The spatial categorization system **600** is

an implementation of the spatial categorization system **110**. The spatial categorization system **600** includes a collector **602**, a database **604**, an analyzer **606**, and a monitor **608**. The collector **602** receives packets of biometric and other data from one or more biometric data collection device **500**. The packets may include the biometric trait measurements **516**, the biometric trait measurements **520**, and the location information **518**. The packets received from the biometric data collection device **500** may be compressed by the biometric data collection device **500** to reduce the amount of data transmitted. The collector **602** decompresses the received packets, and a validation unit **612** validates the packet data. Validation provide by the validation unit **612** may include checking the data received in each packet to ensure that each field corresponds to an expected data or event type. For example, a field identified as EEG data may include a predetermined number of EEG values, a timestamp field identifier, a timestamp value, an activity type identifier and activity type value. A field identified as location data may include a timestamp field identifier, a timestamp value, latitude, longitude, and altitude identifiers, and latitude, longitude, and altitude values.

[0037] After the collector **602** has validated the fields of a packet received from a biometric data collection device **500**, the collector **602** transmits a handshake signal to the biometric data collection device **500** that provided the packet, and transfers the contents of the packet to the database **604**. The database **604** may include a relational database, an object-oriented database, a NoSQL database, or any other type of database suitable for providing storage and retrieval of the biometric data **614** and the location data **616** received from any number of the biometric data collection device **500**.

[0038] The analyzer **606** processes the biometric data **614** and location data **616** stored in the database **604** to categorize the spaces specified by the location information in accordance with the user condition(s) derived from the biometric data **614**. The analyzer **606** determines the spatial location at which each biometric trait measurement of the biometric data **614** was acquired by correlating the time stamps of the biometric trait measurements to the time stamps of the location information of the location data **616**. The analyzer **606** includes event location **618**, event validation **620**, grouping **626**, event resampling **622**, and biometric signal processing **630**.

[0039] The event location **618** applies the time stamps **524** and **526** provided with the biometric trait measurements **516** and the location information **518** to determine the spatial location at which each biometric trait measurement was acquired. For example, a location having a time stamp nearest to the time stamp of a biometric trait measurement may be deemed to be the location at which the biometric trait measurement was acquired.

[0040] The event validation **620** identifies biometric trait measurements provided by the event location **618** that conform to various acquisition rules. For example, rules for acquisition of biometric trait measurements may require that measurements be made within a predetermined geographic area, that the speed of the user while operating in the predetermined geographic area be within a specified range, and/or that the amplitude of the biometric signals acquired be above a specified threshold. Biometric trait measurements not conforming to the rules of acquisition may be discarded or excluded from use in further processing.

[0041] In some implementations of the analyzer **606**, the event validation **620** provides signal validation and spatial validation. In the signal validation process, the validation unit applies signal processing and analysis tools to compare a continuous, periodic biosensor signal (dependent variable) to other relevant (explanatory) variables, including biosensor signals, post-processed signals (e.g. attention, meditation, and heart rate based on the manufacturer's algorithm), and sentiment indicators (e.g. in-app survey responses). Examining if the biosensor signal demonstrates significant patterns when compared to other variables helps to determine whether the signal is too noisy to use in further analysis. For example, raw EEG signals may be used to validate other biometric data. Operations of the signal validation process may include:

[0042] Preparing and cleaning the EEG raw (dependent) and Heart rate, GPS, and data (independent) for analysis. Implementations of the event validation **620** may use Python for analysis, including a variety of analysis libraries.

[0043] Determining thresholds of interest in the independent variable (e.g. heart rate>80 bpm, speed>25 kph).

[0044] Epoching the EEG data (dependent variable) based on those threshold events. This includes band-pass filtering and signal transformations (e.g. Hilbert, Fourier). The band power frequencies listed in Table 1 may be used in some implementations.

[0045] Running temporal regressions and/or outputting histograms to look for significant relationships.

TABLE 1

EEG Band Power Associations

Band Power	Frequencies	Association
Delta	0.1-3 Hertz	Sleep
Theta	4-7 Hertz	Drowsiness and Idling
Alpha (low/high)	8-12 Hertz	Daydreaming, mindfulness
Beta (low/high)	12-30 Hertz	Active thinking, motor behavior, focus, alertness
Gamma (low/high)	30-100 Hertz	Short-term memory, recognition of objects

[0046] In spatial validation, local and global spatial autocorrelation and other spatial techniques are used to test the spatial distribution of the collected data, including biosensor signals and sentiment indicators to evaluate the likelihood that the spatial distribution of a given dataset is random or not random. The greater the likelihood that the dataset is not distributed randomly, the better the dataset is for use in spatial regression and modeling with explanatory variables. For the spatial validation process, the event validation **620** may use the Python Spatial Analysis Library (PySAL), Pandas, GeoPandas, and Shapely. Spatial analysis operations include:

[0047] Subdividing the study area into manageable partitions. Some implementations overlay a grid (e.g., a grid with 150 square foot grid cell size) on the study area. This allows for spatial results that showed high enough resolution to differentiate between street-sized areas, but low enough resolution to be able to process all the biometric datasets. Some implementations divide the study area by actual streets, which may best

reflect the reality of the data collection methodology and yield high-resolution spatial results.

[0048] Processing spatial weights matrices for each data type. A spatial weights matrix quantifies the spatial relationships that exist among the features in a dataset. Some implementations apply a grid-based contiguity approach, using the "Queen" methodology, in which features only need to share one point to be considered adjacent.

[0049] Using the spatial weights calculation to process spatial autocorrelation and spatial lag for each data type in order to understand the data's spatial relationship to the study area; specifically, whether similar and dissimilar features tend to cluster or disperse, and the probability that the clustering or dispersion is the result of random chance.

[0050] Processing local indicators of spatial association (LISA) to show statistically significant areas of clustering and dispersion for dissimilar and similar features.

[0051] The results of the spatial autocorrelation and the LISA process show whether a spatial regression model is an appropriate next step.

[0052] The biometric signal processing **630** processes the biometric trait measurements output by the event validation **620** to prepare for spatial categorization. Signal and spatial validation help to clarify a biosensor dataset's relevance and utility to be included as part of a larger spatial model, in which spatial statistics are employed on all collected data to model how the collected data, namely the biosensor and sentiment indicators from the data collection devices **106**, relate to exogenous data. Exogenous data may include information related to motor vehicle collisions, citizen service requests, bike routes, street types, speed limit, street density, subway entrances, tree counts, and other data acquired from sources other than the data collection devices **106**. Some implementations of the biometric signal processing **630** apply linear regression to examine the relationship of endogenous and exogenous data.

The operations of spatial modeling include:

[0053] Fetching endogenous data (collected by the data collection device **106**) from the database **604**.

[0054] Fetching exogenous data, for the same date range as the endogenous data from appropriate sources external to the spatial categorization system **600**.

[0055] Applying grid (e.g., a 150-meter grid) that bounds the geographic area in which the endogenous data was acquired.

[0056] Using the grid to subdivide both exogenous and endogenous data sets.

[0057] Serializing and caching all "gridified" data sets to facilitate their use during and between interactive analysis sessions. This is especially beneficial for endogenous biometric datasets, which may be tens of gigabytes in size. Exogenous data, collected at much lower frequencies than the endogenous biometric and sentiment data, are generally much more manageable in size than the endogenous data, but serializing and caching all fetched data helps to speed the runtime of the exploratory regression.

[0058] Loading all cached data.

[0059] Spatially joining exogenous data, endogenous data, and the grid.

[0060] Cleaning up artifacts (non-data columns) derived from the spatial join.

[0061] Trimming the joined data to the study area.

[0062] Running a regression (e.g., an OLS (ordinary least squares) regression) on the joined data. For each regression, one endogenous data type (e.g. EEG low beta) is chosen as the dependent variable, and a short list of around 10 exogenous data types are chosen as independent variables.

[0063] Evaluating the results and removing independent variables from the model.

[0064] In some implementations of the biometric signal processing **630**, the EEG measurements are pre-processed and filtered into bands (e.g., gamma, beta, alpha, theta, and/or delta). The pre-processing may include electro-oculogram (EOG) processing to remove eye blinks artifacts from the EGG data, and/or applying interpolation to fill gaps in the EEG data. The condition (a level of stress, relaxation, etc.) of the user is derived from the amplitude of the EEG signal in one or more bands. For example, the amplitude (or power) of the EGG signal in the various bands may be compared to thresholds, where the thresholds applied to each band are indicative of various conditions of the user. Similarly, heart rate, or changes in heart rate, may be compared to thresholds that are indicative of various conditions of the user. Thus, the biometric signal processing **630** may determine a condition of each user in a space based on the biometric trait measurements acquired for the user while in the space.

[0065] The biometric signal processing **630** categorizes space based on the conditions assigned to users operating in the space. For example, given data from multiple users operating in a space, the biometric signal processing **630** may average condition values, apply a majority condition value, or most frequent condition value to assign a category identification value to a space. Category identification values assigned to spaces may correspond to the user condition values from the category identification values are derived. For example, a category identification value of "stressful" may result from a user condition indicating stress. Similarly, a category identification value of "relaxed" may result from the user condition indicating relaxation. In some implementations, a value of condition is compared to one or more threshold values to select a category identification value. For example, a user condition value may indicate a variable degree of relaxation. If the condition value exceeds a threshold, then a category identification value for a corresponding space may be set to indicate that the space induces relaxation. Similarly, a user condition value may indicate a variable degree of stress. If the condition value exceeds a threshold, then a category identification value for a corresponding space may be set to indicate that the space induces stress. Implementations of the biometric signal processing **630** may assign a variety of condition values and category identification values to represent user conditions and an attribute of a physical space, stress and relaxation are only two examples of condition values and category identification values that may be applied in implementations of the system **100**.

[0066] The grouping **626** identifies (or groups) the biometric trait measurements and associated location information selected by the event validation **620** as conforming to the rules of acquisition that were acquired from a given user.

That is, the grouping **626** groups by user the biometric trait measurements and associated location information validated by the event validation **620**.

[0067] The event resampling **622** resamples (e.g., decimates) the biometric trait measurements and associated location information selected by the event validation **620** to reduce the number of measurements used to generate a map displaying the geographic area over which biometric trait measurements are to be acquired and the specific locations within the geographic area at which biometric trait measurements have been acquired.

[0068] The statistics **628** generate, from the output of the grouping **626**, ranking for each user (e.g., each user in relation to other users) based on the received biometric trait measurements (e.g., the quantity of measurements and/or size of space traversed). The **628** may also generate for each user a summary of activity detailing the user's notes and comments, validated biometric trait measurements, usage of the biometric data collection device **106**, etc.

[0069] The monitor **608** applies the output of the analyzer **606** to generate a map of a geographic area. The map includes a representation of a spatial area (e.g., streets, blocks, building interior, or other area) to be categorized based on the biometric trait measurements acquired by the system **100**. The monitor **608** overlays on the representation of the spatial area identification values the category identification values generated by the biometric signal processing **630** based on the condition of one or more users derived from biometric trait measurements collected in the geographic area. For example, in a first space in which the biometric trait measurements indicate a user exhibits a first condition (e.g., relaxation), the monitor **608** may add a first color to the map as representative of a first category identification value, while in a second space in which the biometric trait measurements indicate a user exhibits a second condition (e.g., stress), the monitor **608** may add a second color to the map as representative of a second category identification value. FIG. **9** shows an example of a map of a geographic area divided in a number of subareas (e.g., blocks), and each block assigned a category identification value (e.g., a color value) that indicates a condition of one or more users of the system **100** operating in the subarea.

[0070] Some implementations of the monitor **608** may also generate a list of all users of the system **100** present in a geographic area on any given day. The list may include a variety of data provided by each user. Such data may include: number of EEG samples provided, number of heart rate samples provided, number of minutes operating in the area, etc.

[0071] The monitor **608** may also provide an individualized display for each user that is viewable via the biometric data collection device **106** or a web page. The individualized display may show spaces in which the user has acquired biometric trait measurements, and/or a summary of the data provided by the user as generated by the statistics **628**.

[0072] FIG. **7** shows a schematic diagram for a computing system **700** suitable for implementation of the spatial categorization system **600**. The computing system **700** includes one or more computing nodes **702** and secondary storage **716** that are communicatively coupled via a network **718**. One or more of the computing nodes **702** and associated secondary storage **716** may be applied to provide the functionality of the spatial categorization system **600**, including the collector **602**, the database **604**, the analyzer **606**, the monitor **608**, etc.

[0073] Each computing node **702** includes one or more processors **704** coupled to memory **706**, network interface **712**, and I/O devices **714**. In some embodiments of the spatial categorization system **600**, a computing node **702** may implement the functionality of more than one component of the spatial categorization system **600**. In various embodiments, a computing node **702** may be a uniprocessor system including one processor **704**, or a multiprocessor system including several processors **704** (e.g., two, four, eight, or another suitable number). Processors **704** may be any suitable processor capable of executing instructions. For example, in various embodiments, processors **704** may be general-purpose or embedded microprocessors implementing any of a variety of instruction set architectures (ISAs), such as the x86, PowerPC, SPARC, or MIPS ISAs, or any other suitable ISA. In multiprocessor systems, each of processors **704** may commonly, but not necessarily, implement the same ISA. Similarly, in a distributed computing system such as one that collectively implements the spatial categorization system **600**, each of the computing nodes **702** may implement the same ISA, or individual computing nodes and/or replica groups of nodes may implement different ISAs.

[0074] The memory **706** may include a non-transitory computer-readable storage medium configured to store program instructions **708** and/or data **710** accessible by processor(s) **704**. The memory **706** may be implemented using any suitable memory technology, such as static random-access memory (SRAM), synchronous dynamic RAM (SDRAM), nonvolatile/Flash-type memory, or any other type of memory. Program instructions **708** and data **710** implementing the functionality disclosed herein are stored within system memory **706**. For example, instructions **708** may include instructions that when executed by processor(s) **704** implement the collector **602**, the database **604**, the analyzer **606**, the monitor **608**, and/or other components of the spatial categorization system **600** disclosed herein.

[0075] Secondary storage **716** may include volatile or non-volatile storage and storage devices for storing information such as program instructions and/or data as described herein for implementing the spatial categorization system **600**. The secondary storage **716** may include various types of computer-readable media accessible by the computing nodes **702** via the network **718**. A computer-readable medium may include storage media or memory media such as semiconductor storage, magnetic or optical media, e.g., disk or CD/DVD-ROM, or other storage technologies. Program instructions and data stored on the secondary storage **716** may be transmitted to a computing node **702** for execution by a processor **704** by transmission media or signals via the network **718**, which may be a wired or wireless network or a combination thereof.

[0076] The network interface **712** may be configured to allow data to be exchanged between computing nodes **702** and/or other devices coupled to the network **718** (such as other computer systems, communication devices, input/output devices, or external storage devices). The network interface **712** may support communication via wired or wireless data networks, such as any suitable type of Ethernet network, for example; via telecommunications/telephony networks such as analog voice networks or digital fiber

communications networks; via storage area networks such as Fibre Channel SANS, or via any other suitable type of network and/or protocol.

[0077] Input/output devices **714** may include one or more display terminals, keyboards, keypads, touchpads, scanning devices, voice or optical recognition devices, or any other devices suitable for entering or retrieving data by one or more computing nodes **702**. Multiple input/output devices **714** may be present in a computing node **702** or may be distributed on various computing nodes **702** of the system **700**. In some embodiments, similar input/output devices may be separate from computing node **702** and may interact with one or more computing nodes **702** of the system **100** through a wired or wireless connection, such as over network interface **712**.

[0078] Those skilled in the art will appreciate that computing system **700** is merely illustrative and is not intended to limit the scope of embodiments. In particular, the computing system **700** may include any combination of hardware or software that can perform the functions disclosed herein, including computers, network devices, Internet appliances, PDAs, wireless phones, pagers, etc. Computing node **702** may also be connected to other devices that are not illustrated, in some embodiments. In addition, the functionality provided by the illustrated components may in some embodiments be combined in fewer components or distributed in additional components. Similarly, in some embodiments the functionality of some of the illustrated components may not be provided and/or other additional functionality may be available.

[0079] FIG. **8** shows a flow diagram for a method **800** for spatial categorization in accordance with the present disclosure. Though depicted sequentially as a matter of convenience, at least some of the actions shown can be performed in a different order and/or performed in parallel. Additionally, some implementations may perform only some of the actions shown. Operations of the method **800** may be performed by implementations of the system **100**.

[0080] In block **802**, one or more users are operating in a space, and the biometric device **102** and/or the biometric device **104** attached to the users are measuring biometric traits, such as brain electrical activity or heart rate each user.

[0081] In block **804**, the biometric device **102** and/or the biometric device **104** transmit the acquired biometric trait measurements to a biometric data collection device **106**. The biometric data collection device **106** may be carried by or otherwise located proximate the user.

[0082] In block **806**, the biometric data collection device **106** determines the geographic location of the biometric data collection device **106** while the biometric device **102** and/or the biometric device **104** are acquiring biometric trait measurements.

[0083] In block **808**, the biometric data collection device **106** time stamps the location information generated in block **806** and the biometric trait measurements received from the biometric device **102** and/or the biometric device **104**. The time stamped location information and biometric trait measurements are stored in internal memory of the biometric data collection device **106**.

[0084] In block **810**, the biometric data collection device **106** transmits the time stamped location information and biometric trait information to the spatial categorization system **110**.

[0085] In block **812**, the spatial categorization system **110** stores the stamped location information and biometric trait information in a database **604** of the spatial categorization system **110**.

[0086] In block **814**, the spatial categorization system **110** retrieves the stamped location information and biometric trait information from the database **604** and associates the biometric trait measurements with a physical space by correlation of the time stamps assigned to the location information and the biometric trait information. The spatial categorization system **110** processes the biometric trait measurements to produce values that assign a condition to the user.

[0087] In block **816**, the spatial categorization system **110** categorizes one or more spaces based on the conditions assigned to users in the spaces based on the biometric trait measurements acquired in the spaces.

[0088] Those skilled in the art will also appreciate that in some embodiments the functionality disclosed herein may be provided in alternative ways, such as being split among more software modules or routines or consolidated into fewer modules or routines. Similarly, in some embodiments illustrated methods may provide more or less functionality than is described, such as when other illustrated methods instead lack or include such functionality respectively, or when the amount of functionality that is provided is altered. In addition, while various operations may be illustrated as being performed in a particular manner (e.g., in serial or in parallel) and/or in a particular order, those skilled in the art will appreciate that in other embodiments the operations may be performed in other orders and in other manners. The various methods as depicted in the figures and described herein represent illustrative embodiments of methods. The methods may be implemented in software, in hardware, or in a combination thereof in various embodiments. Similarly, the order of any method may be changed, and various elements may be added, reordered, combined, omitted, modified, etc., in various embodiments.

[0089] The above discussion is meant to be illustrative of the principles and various embodiments of the present invention. Numerous variations and modifications will become apparent to those skilled in the art once the above disclosure is fully appreciated. It is intended that the following claims be interpreted to embrace all such variations and modifications.

What is claimed is:

1. A system, comprising:

a biometric device, comprising:

a biometric sensor configured to measure a biometric trait of a user; and

a first wireless transceiver circuit configured to transmit biometric trait measurements;

a biometric data collection device comprising:

a second wireless transceiver circuit configured to receive the biometric trait measurements transmitted by the biometric device;

a positioning system configured to provide spatial location values specifying a geographic location of the biometric data collection device;

a biometric data storage system configured to:

assign time stamp values to:

each of the biometric trait measurements; and

each of the spatial location values;

store the biometric trait measurements, the spatial location values, and the assigned time stamp values; and

a third wireless transceiver circuit configured to transmit the biometric trait measurements the spatial location values, and the assigned time stamp values;

a spatial categorization system configured to:

receive the biometric trait measurements the spatial location values, and the assigned time stamp values;

associate each of the biometric trait measurements with one of the spatial location values based on time stamp values;

identify a first of the biometric trait measurements indicating that a first condition of the user has a value that exceeds a first threshold;

identify a second of the biometric trait measurements indicating that a second condition of the user has a value that exceeds a second threshold;

assign, based on the identified first of the biometric trait measurements, a first category identification value to a first spatial region corresponding to the spatial location value associated with the identified first of the biometric trait measurements; and

assign, based on the identified second of the biometric trait measurement, a second category identification value to a second spatial region corresponding to the spatial location value associated with the identified second of the biometric trait measurements.

2. The system of claim **1**, wherein the biometric sensor is an electroencephalography electrode.

3. The system of claim **1**, wherein the first wireless transceiver circuit and the second wireless transceiver circuit are configured to communicate via personal area network.

4. The system of claim **1**, wherein the third wireless transceiver circuit is configured to communicate via a wide area network.

5. The system of claim **1**, wherein the biometric data collection device is a cellular handset.

6. The system of claim **1**, wherein the biometric device is a first biometric device and the biometric trait is a first biometric trait, and biometric trait measurements are first biometric trait measurements, and the system further comprises:

a second biometric device, comprising:

a second biometric sensor configured to measure a second biometric trait of the user; and

a fourth wireless transceiver circuit configured to transmit second biometric trait measurements corresponding to the second biometric trait to the biometric data collection device.

7. The system of claim **6**, wherein the second biometric sensor is a heart rate sensor.

8. The system of claim **6**, wherein the spatial categorization system is configured to:

receive the second biometric trait measurements and time stamp values assigned to the second biometric trait measurements;

associate each of the second biometric trait measurements with one of the spatial location values based on time stamp values;

identify a first of the second biometric trait measurement indicating that the first condition of the user has a value that exceeds the first threshold;

identify a second of the second biometric trait measurements indicating that the second condition of the user has a value that exceeds the second threshold;

assign, based on the identified first of the second biometric trait measurements, the first category identification value to the first spatial region corresponding to the spatial location value associated with the identified first of the second biometric trait measurements; and

assign, based on the identified second of the second biometric trait measurements, the second category identification value to the second spatial region corresponding to the spatial location value associated with the identified second of the second biometric trait measurements.

9. The system of claim **1**, further comprising:

a plurality of biometric devices and a plurality of biometric data collection devices, wherein each of the biometric devices and each of the biometric data collection devices is configured provide to the spatial categorization system biometric trait measurements of a different user; and

wherein the spatial categorization system is configured to assign, based on the biometric trait measurements received from the plurality of biometric data collection devices, a category identification value to each of a plurality of spatial regions in which the biometric devices are operated.

10. The system of claim **1**, wherein the spatial categorization system comprises:

a database configured to store the biometric trait measurements and the spatial location information;

a collection unit configured to:

receive information from the biometric data collection device, the information comprising the biometric trait measurements and the spatial location values;

decompress the information;

validate the information;

store the information in the database; and

notify the biometric data collection device of receipt of the information;

an analysis unit configured to:

retrieve from the database, information comprising:

the biometric trait measurements and the spatial location values; and

attribute data corresponding to the spatial locations defined by the assigned spatial location information; and

user comments directed to the spatial locations at which the biometric trait measurements are acquired; and

process the information retrieved from the database to categorize the spatial locations defined by the assigned spatial location information.

11. A method, comprising:

measuring, by a first biometric sensing device, a first biometric trait of a user;

assigning a timestamp to each measurement of the first biometric trait;

transmitting measurements of the first biometric trait to a biometric data collection device via a wireless personal area network;

determining, by a positioning system of the biometric data collection device, spatial location values defining a spatial location of the biometric data collection device;

assigning a timestamp to each spatial location value;

transmitting, by the biometric data collection device, the measurements of the first biometric trait and the spatial location values to a spatial categorization system via a wide area network;

identifying, by the spatial categorization system, a first of the measurements of the first biometric trait indicating that a first condition of the user has a value that exceeds a first threshold;

assigning, by the spatial categorization system, based on the first of the measurements of the first biometric trait, a first category identification value to a first spatial region corresponding to a spatial location value associated by the time stamps with the first of the measurements of the first biometric trait.

12. The method of claim **11**, further comprising:

identifying, by the spatial categorization system, a second of the measurements of the first biometric trait indicating that a second condition of the user has a value that exceeds a second threshold;

assigning, by the spatial categorization system, based on the second of the measurements of the first biometric trait, a second category identification value to a second spatial region corresponding to the spatial location values associated by the time stamps with the second of the measurements of the first biometric trait.

13. The method of claim **11**, wherein measuring the first biometric trait comprises acquiring electroencephalography signals from the user.

14. The method of claim **11**, wherein the biometric data collection device is a cellular handset, and the wide area network comprises a cellular data communication network.

15. The method of claim **11**, further comprising:

measuring, by a second biometric sensing device, a second biometric trait of the user;

transmitting measurements of the second biometric trait to the biometric data collection device via the wireless personal area network;

transmitting, by the biometric data collection device, the measurements of the second biometric trait to the spatial categorization system via the wide area network;

identifying, by the spatial categorization system, a first of the measurements of the second biometric trait indicating that a first condition of the user has a value that exceeds the first threshold; and

assigning, by the spatial categorization system, based on the first of the measurements of the second biometric trait, the first category identification value to the first spatial region corresponding to the spatial location values associated by the time stamps with the second of the measurements of the first biometric trait.

16. The method of claim **15**, further comprising:

identifying, by the spatial categorization system, a second of the measurements of the second biometric trait indicating that a second condition of the user has a value that exceeds a second threshold;

assigning, by the spatial categorization system, based on the second of the measurements of the second biometric trait, the second category identification value to the second spatial region corresponding to the spatial location values associated by the time stamps with the measurements of the second biometric trait.

17. The method of claim **15**, measuring the second biometric trait comprises acquiring heart rate signals from the user.

18. A system, comprising:

an electroencephalography (EEG) device, comprising:

an EEG sensor configured to measure electrical activity in a brain of a user; and

a first wireless transceiver circuit configured to transmit EEG measurements;

a heart rate measurement device, comprising:

a heart rate sensor configured to measure heart rate of the user; and

a second wireless transceiver circuit configured to transmit heart rate measurements;

a biometric data collection device comprising:

a third wireless transceiver circuit configured to receive the EEG measurements and the heart rate measurements;

a positioning system configured to provide spatial location information specifying a geographic location of the biometric data collection device;

a biometric data storage system configured to:

assign time stamps to the spatial location information, the EEG measurements, and the heart rate measurements;

store the EEG measurements, the heart rate measurements, and the spatial location information; and

a fourth wireless transceiver circuit configured to transmit the EEG measurements, the heart rate measurements, and the spatial location information;

a spatial categorization system configured to:

receive the EEG measurements, the heart rate measurements, and the assigned spatial location information;

identify a first of the EEG measurements and a first of heart measurements indicating that a first condition of the user has a value that exceeds a first threshold;

identify a second of the EEG measurements and a second of the heart rate measurements indicating that a second condition of the user has a value that exceeds a second threshold;

assign, based on the first of the EEG measurements and the first of heart rate measurements, a first category identification value to a first spatial region corresponding to the spatial location information associated by the time stamps with the first of the EEG measurements and the first of heart rate measurements; and

assign, based on the second of the EEG measurements and the second of ECG measurements, a second category identification value to a second spatial region corresponding to the spatial location information associated by the time stamps with the second of the EEG measurements and the second of heart rate measurements.

19. The system of claim **18**, further comprising:

a plurality of biometric data collection devices, each of the biometric data collection devices associated with a different user; wherein each of the biometric data collection devices is coupled to an EEG device and a heart rate device, and is configured to transmit EEG measurements and heart rate measurements to the spatial categorization system; and

the spatial categorization system is configured to assign, based on the EEG measurements and heart rate measurements received from the plurality of biometric data collection devices, a category identification value to each of a plurality of spatial regions in which the EEG devices and the heart rate devices are operated.

20. The system of claim **18**, wherein the spatial categorization system comprises:

a database configured to store the EEG measurements, the heart rate measurements, and the spatial location information;

a collection unit configured to:

receive information from the biometric data collection device, the information comprising the EEG measurements, the heart rate measurements, and the spatial location information;

decompress the information;

validate the information;

store the information in the database; and

notify the biometric data collection device of receipt of the information;

an analysis unit configured to:

retrieve from the database, information comprising:

the EEG measurements, the heart measurements, and the spatial location information;

attribute data corresponding to the spatial locations defined by the spatial location information; and

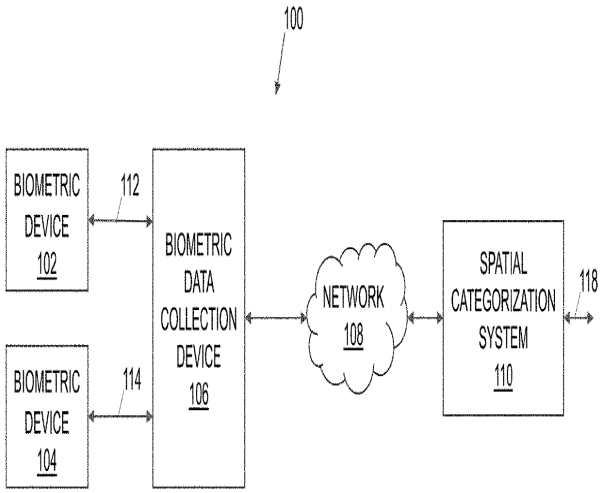
user comments directed to the spatial locations at which the EEG measurements and the ECG measurements are acquired;

associate the EEG measurements and the heart measurements with the spatial location information based on the time stamps; and

process the information retrieved from the database to categorize the spatial locations defined by the spatial location information.

* * * * *

专利名称(译)	基于生物特征的空间分类的系统和方法		
公开(公告)号	US20200000337A1	公开(公告)日	2020-01-02
申请号	US16/452823	申请日	2019-06-26
[标]发明人	WILLARD CHRISTOPHER		
发明人	DUCAO, ARLENE KOEN, ILIAS WILLARD, CHRISTOPHER BERRY, YAPAH		
IPC分类号	A61B5/00 A61B5/0478 A61B5/024 G06F16/906 G06F16/909 G06F16/908 H04W4/029		
CPC分类号	G06F16/906 A61B5/0478 H04W4/029 A61B5/02438 G06F16/908 A61B5/0022 G06F16/909 A61B5/0205 A61B5/1112 A61B2503/10 G16H15/00 G16H40/67 H04W4/02		
优先权	62/692789 2018-07-01 US		
外部链接	Espacenet USPTO		

摘要(译)

一种系统，包括生物识别设备，生物识别数据收集设备和空间分类系统。 该生物特征识别装置包括用于测量用户的生物特征的生物特征传感器。 生物数据收集设备包括定位系统和生物数据存储系统，以及第三无线收发器。 定位系统被配置为提供指定生物统计数据收集设备的地理位置的空间位置值。 生物特征数据存储系统被配置为将时间戳值分配给每个空间位置值和生物特征特征测量。 空间分类系统被配置为识别指示用户的状况具有超过阈值的值的生物特征测量，并基于所识别的生物特征测量将类别识别值分配给与该特征相对应的空间区域。 空间位置值。