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(54) **PERSONAL DATA ANALYTICS SYSTEM**

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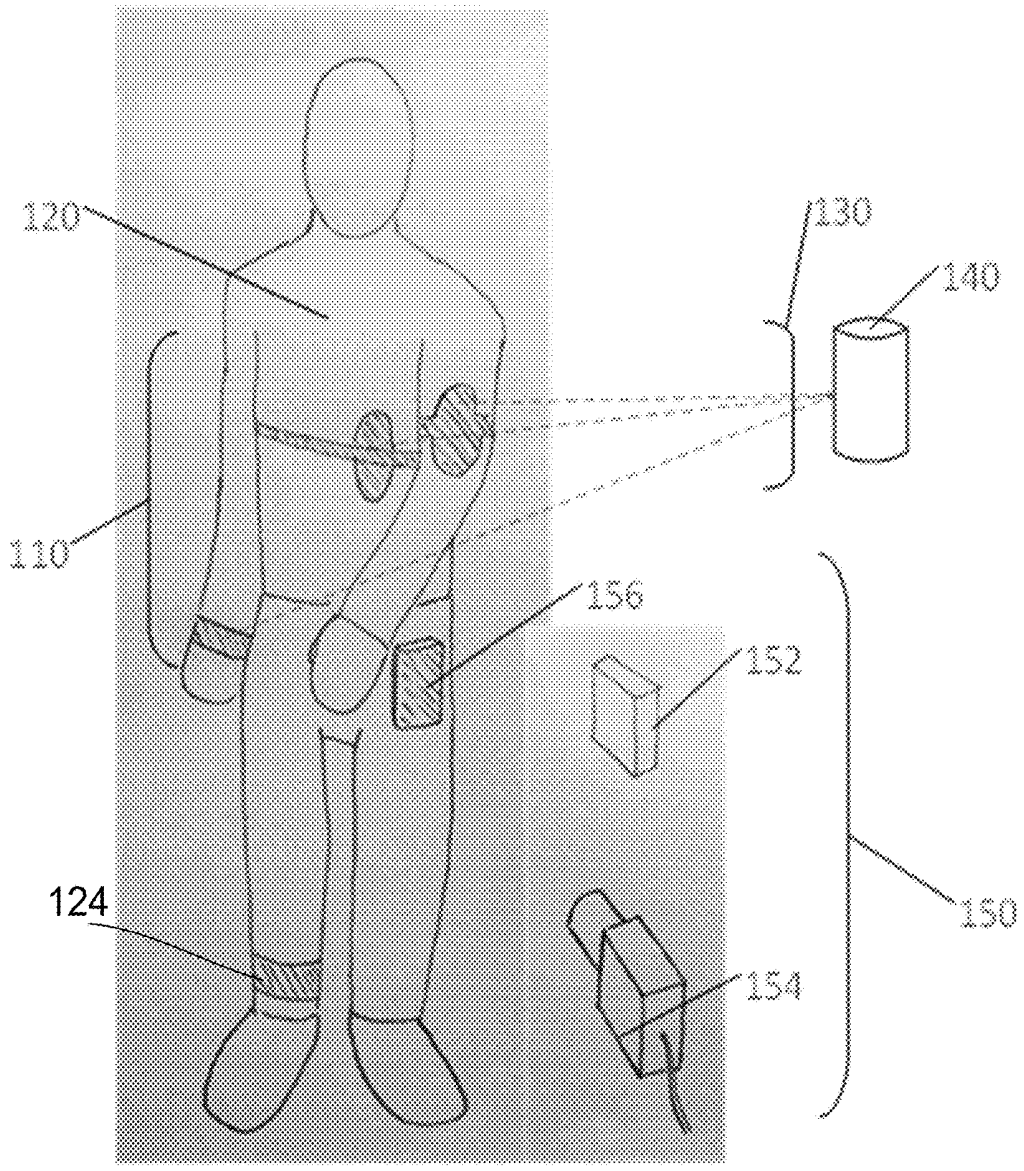
G16H 10/60	(2006.01)
A61B 5/00	(2006.01)

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

CPC ***G16H 50/30*** (2018.01); ***G16H 10/60*** (2018.01); ***A61B 5/746*** (2013.01); ***A61B 5/7435*** (2013.01); ***A61B 5/6833*** (2013.01); ***A61B 5/7282*** (2013.01)

(57) **ABSTRACT**

Example inventions evaluate a health of a user. Example inventions receive, from a plurality of disparate data sources, health data corresponding to the user, the plurality of disparate data sources including two or more of biometric data, activity monitoring, or an electronic health record. Example inventions correlate the disparate data sources onto a common timeline. Example inventions generate a user interface that displays the correlated data sources simultaneously with the common timeline.



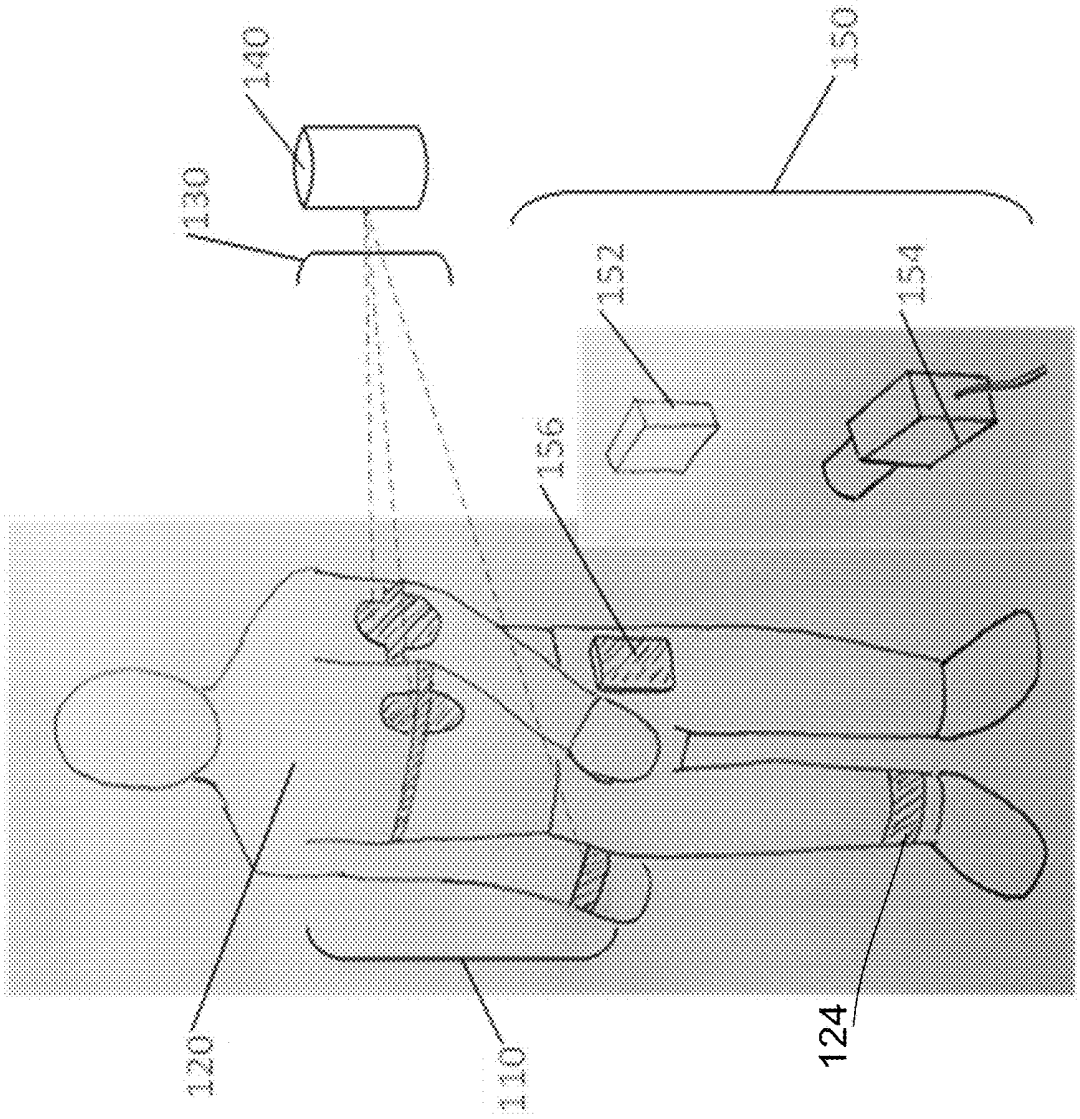


Fig. 1

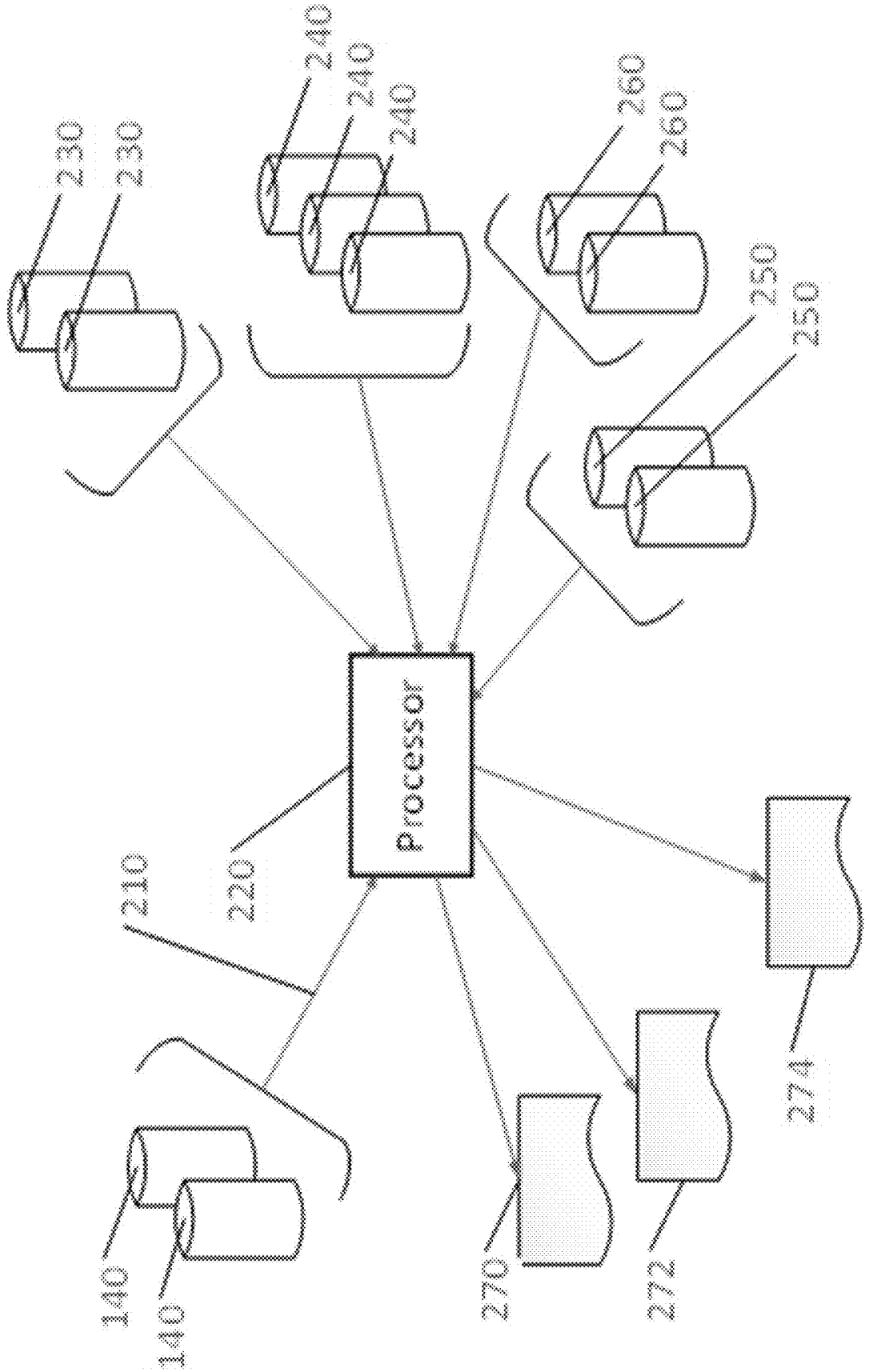

240
240
240
260
260
230
230
250
250
Processor
210
220
140
140
270
272
274

Fig. 2

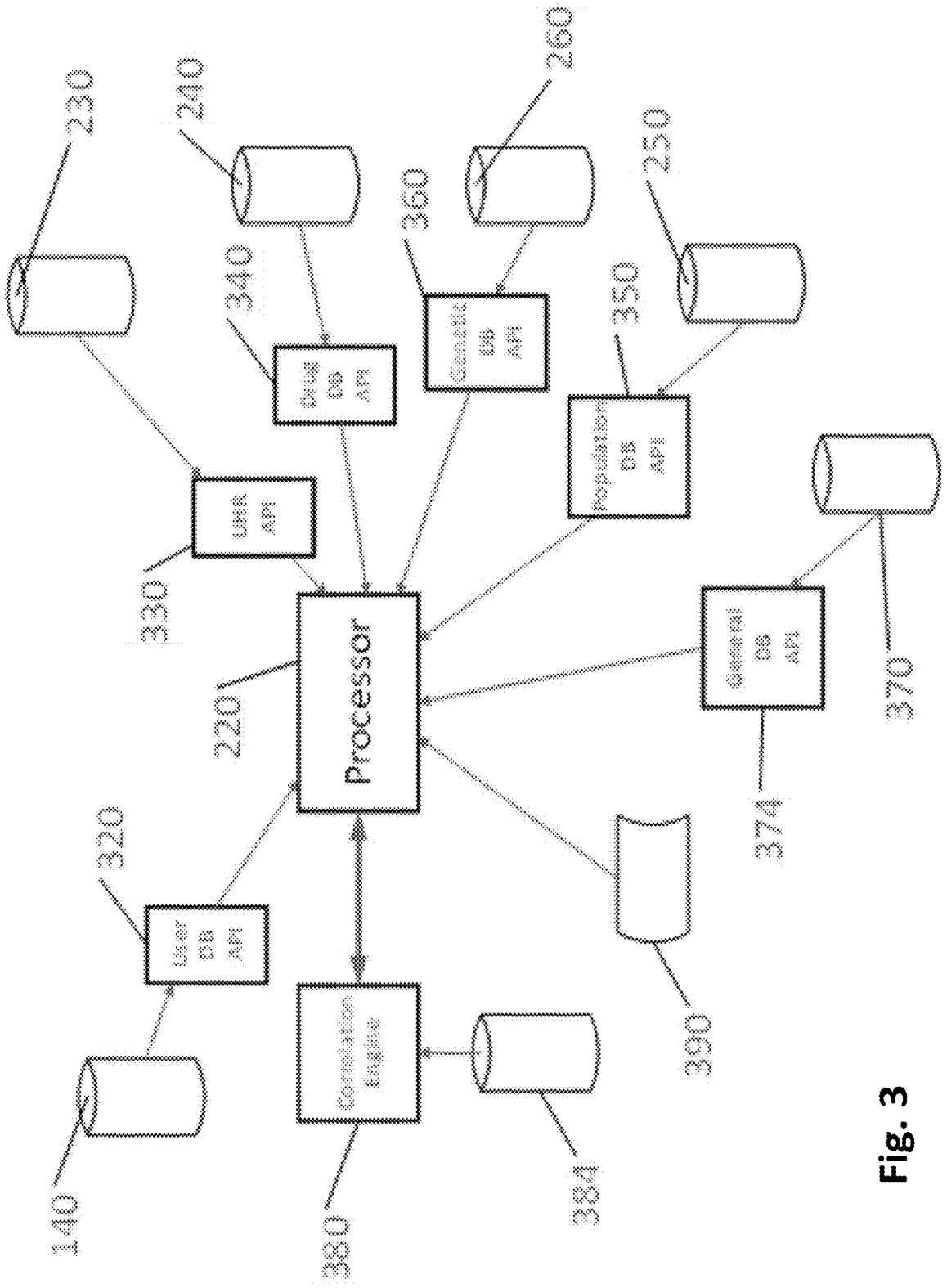

230
240
260
250
360
340
350
330
220
Processor
320
370
374
390
140
380
384

Fig. 3

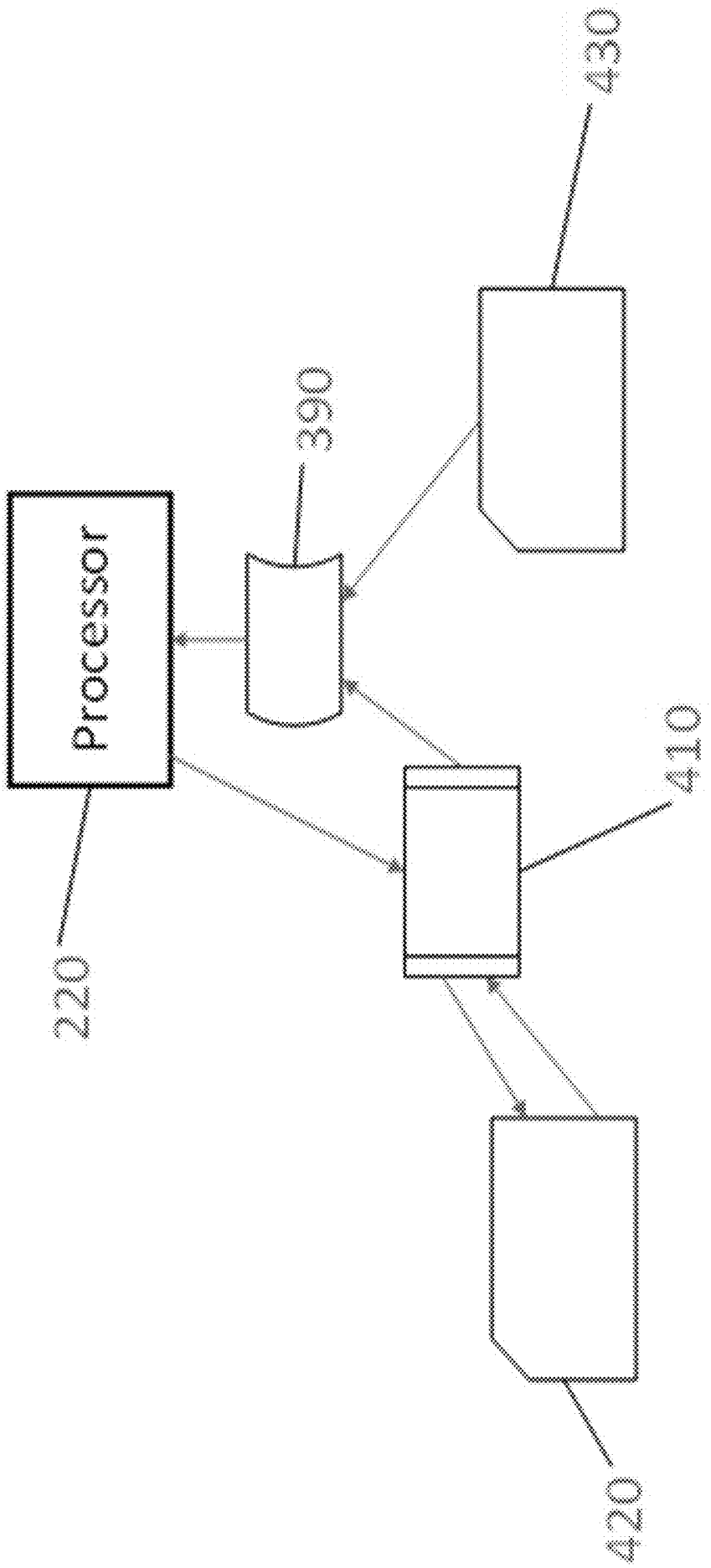


Fig. 4

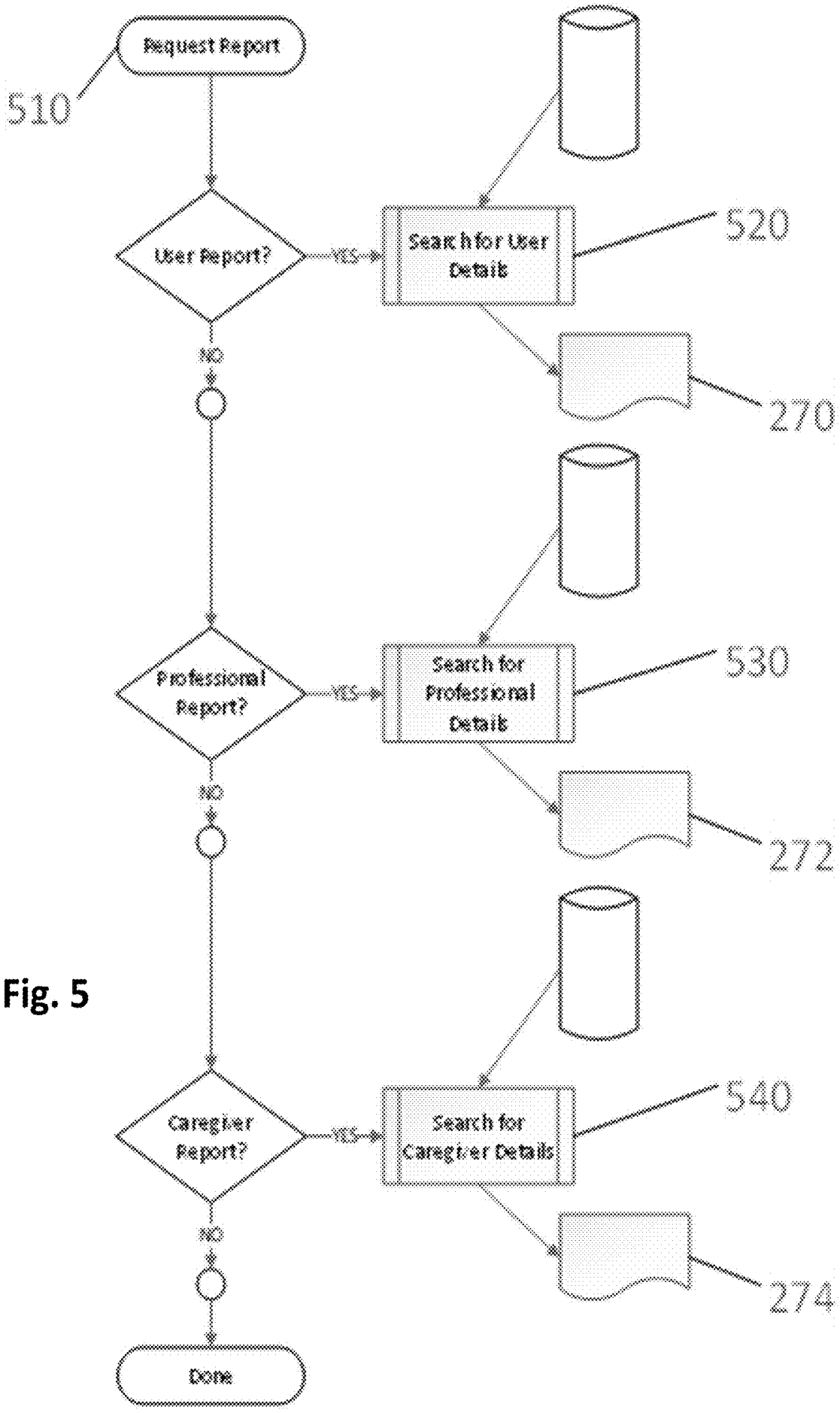

Request Report
510
User Report?
YES
Search for User Details
520
NO
270
Professional Report?
YES
Search for Professional Details
530
NO
272
Caregiver Report?
YES
Search for Caregiver Details
540
NO
274
Done

Fig. 5

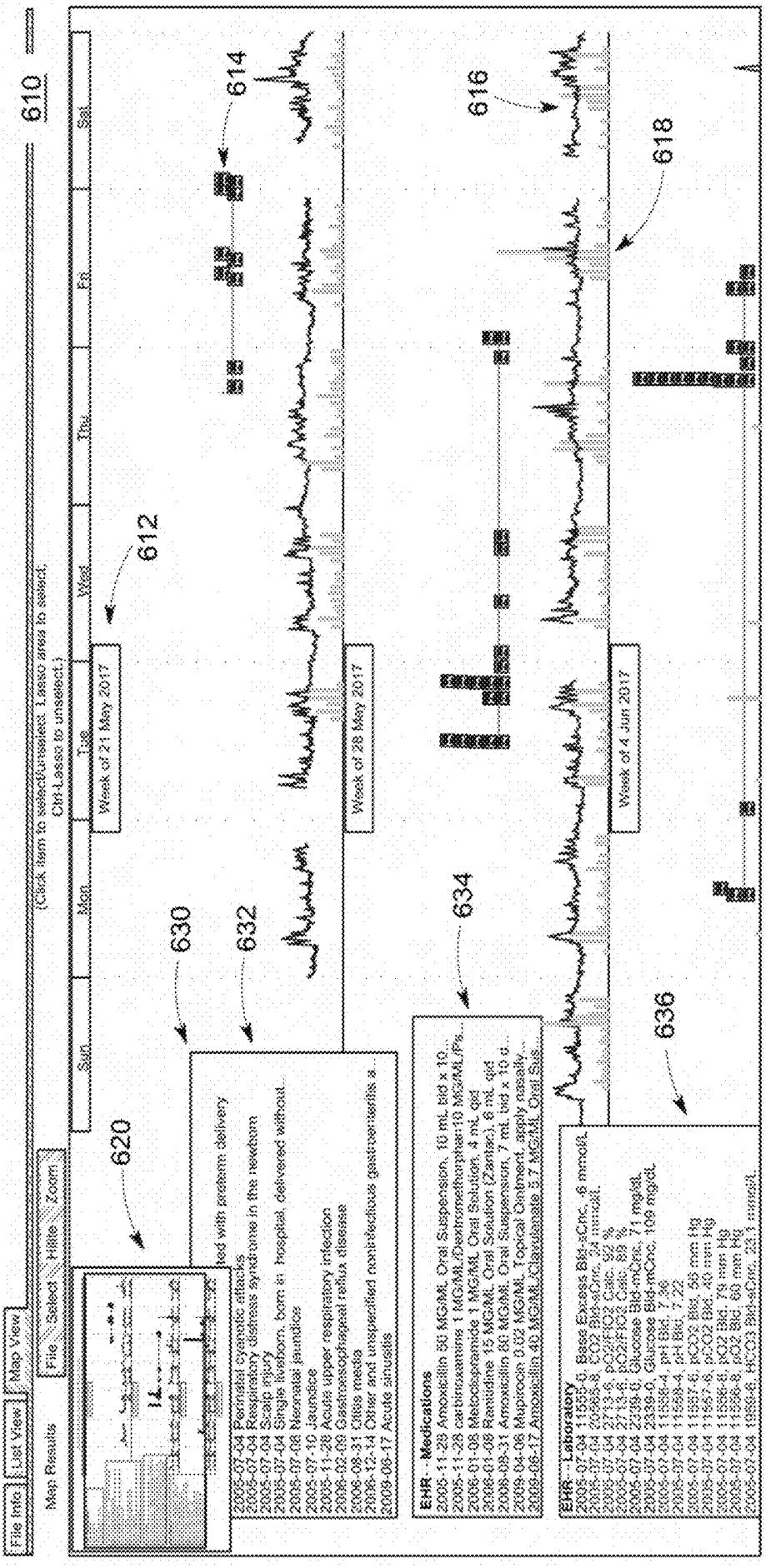

610
File Info
List View
Map View
Map Results
File
Select
Hilite
Zoom
(Click item to select/unselect. Lasso area to select.
Ctrl-Lasso to unselect.)
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Week of 21 May 2017
Week of 28 May 2017
Week of 4 Jun 2017
612
614
616
618
620
630
632
634
636
ted with preterm delivery
2005-07-04 Perinatal cyanotic attacks
2005-07-04 Respiratory distress syndrome in the newborn
2005-07-04 Scalp injury
2005-07-04 Single liveborn, born in hospital, delivered without...
2005-07-08 Neonatal jaundice
2005-07-10 Jaundice
2005-11-28 Acute upper respiratory infection
2006-02-09 Gastroesophageal reflux disease
2006-08-31 Otitis media
2006-12-14 Other and unspecified noninfectious gastroenteritis a...
2009-06-17 Acute sinusitis
EHR - Medications
2005-11-28 Amoxicillin 50 MG/ML Oral Suspension, 10 mL tid x 10...
2005-11-28 carbinoxamine 1 MG/ML/Dextromethorphan-10 MG/ML/Ps...
2006-01-08 Metoclopramide 1 MG/ML Oral Solution, 4 mL qid
2006-01-08 Ranitidine 15 MG/ML Oral Solution (Zantac), 8 mL qid
2008-08-31 Amoxicillin 80 MG/ML Oral Suspension, 7 mL bid x 10 d...
2009-04-06 Mupirocin 0.02 MG/ML Topical Ointment, apply nasally...
2009-06-17 Amoxicillin 40 MG/ML/Clavulanate 5.7 MG/ML Oral Sus...
EHR - Laboratory
2005-07-04 11557-6, Base Excess Bld-sCnc, -6 mmol/L
2005-07-04 20565-8, CO2 Bld-sCnc, 24 mmol/L
2005-07-04 2713-6, pO2/FiO2 Calc, 92 %
2005-07-04 2713-6, pO2/FiO2 Calc, 88 %
2005-07-04 2339-0, Glucose Bld-mCnc, 71 mg/dL
2005-07-04 2339-0, Glucose Bld-mCnc, 109 mg/dL
2005-07-04 11558-4, pH Bld, 7.36
2005-07-04 11558-4, pH Bld, 7.22
2005-07-04 11557-6, pCO2 Bld, 50 mm Hg
2005-07-04 11557-6, pCO2 Bld, 20 mm Hg
2005-07-04 11556-8, pO2 Bld, 60 mm Hg
2005-07-04 1959-6, HCO3 Bld-sCnc, 23.1 mmol/L

FIG. 6A

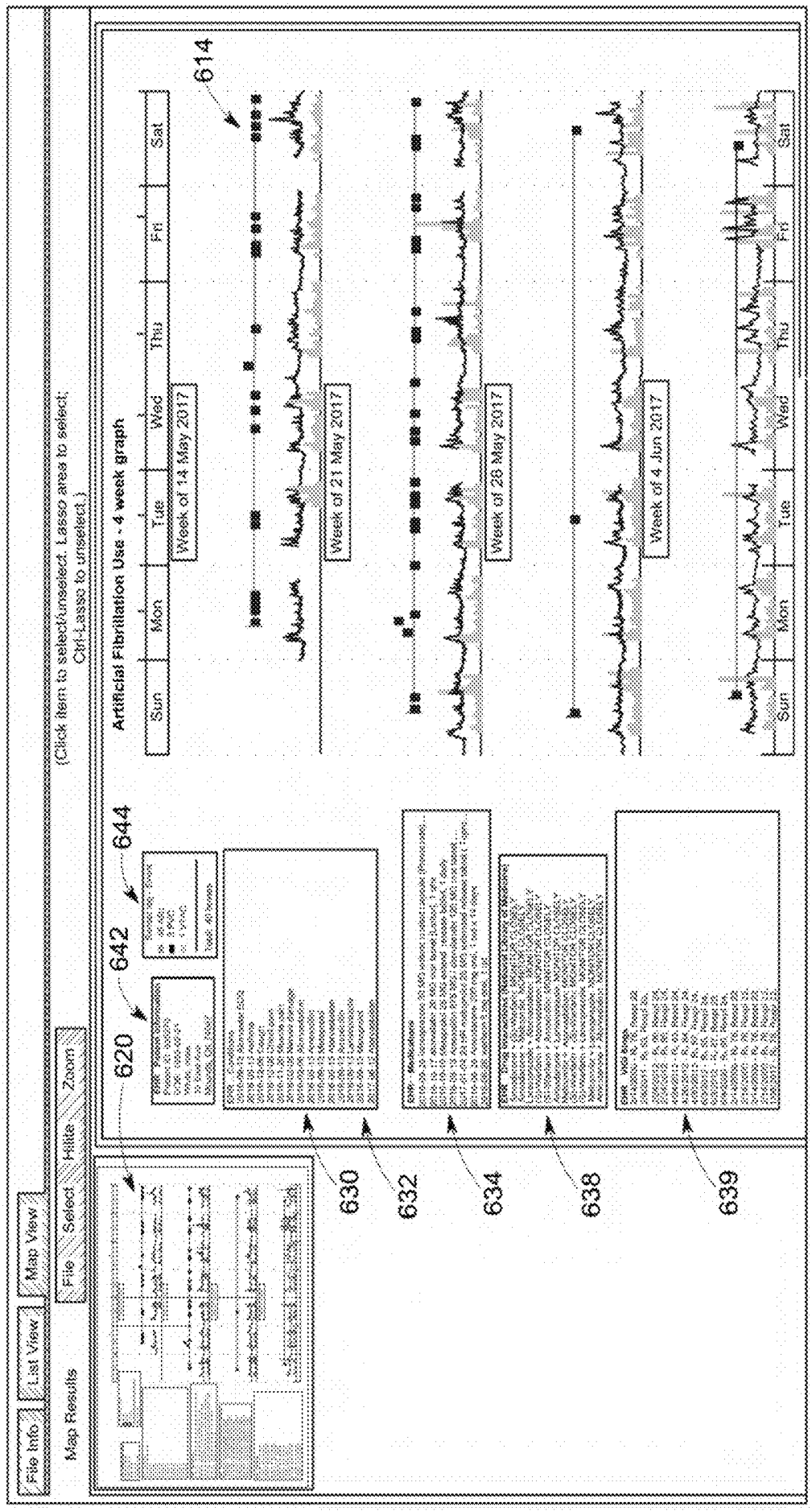

File Info
List View
Map View
Map Results
File
Select
Hilite
Zoom
(Click item to select/unselect. Lasso area to select;
Ctrl-Lasso to unselect.)
Artificial Fibrillation Use - 4 week graph
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Week of 14 May 2017
Week of 21 May 2017
Week of 28 May 2017
Week of 4 Jun 2017
614
620
630
632
634
638
639
642
644

FIG. 6B

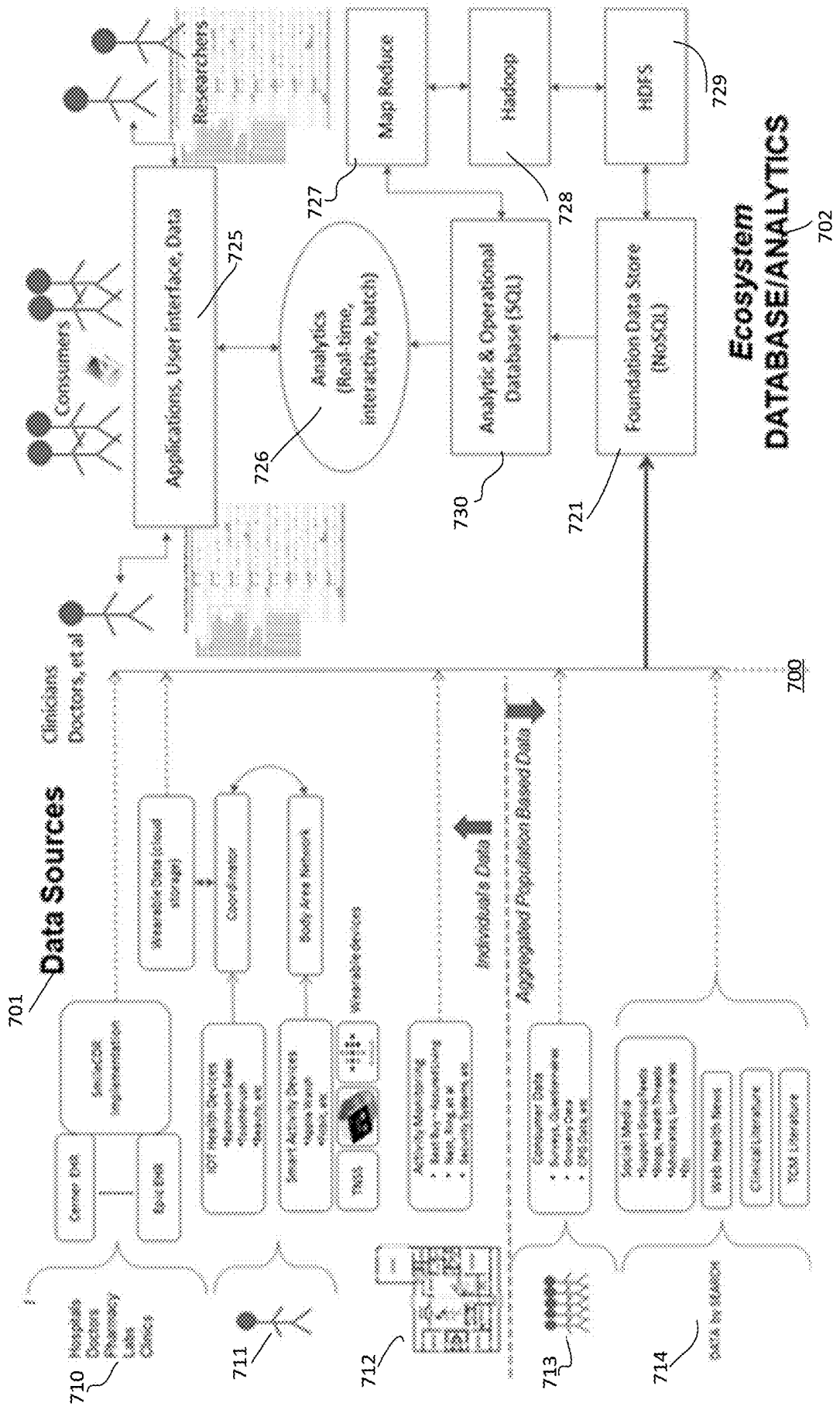

Data Sources
701
Clinicians
Doctors, et al
Consumers
Researchers
Applications, User interface, Data
725
Analytics
(Real-time,
interactive, batch)
726
Map Reduce
727
Hadoop
728
HDFS
729
Analytic & Operational
Database (SQL)
730
Foundation Data Store
(NoSQL)
721
Ecosystem
DATABASE/ANALYTICS
702
700
Individual Data
Aggregated Population Based Data
710
711
712
713
714

Fig. 7

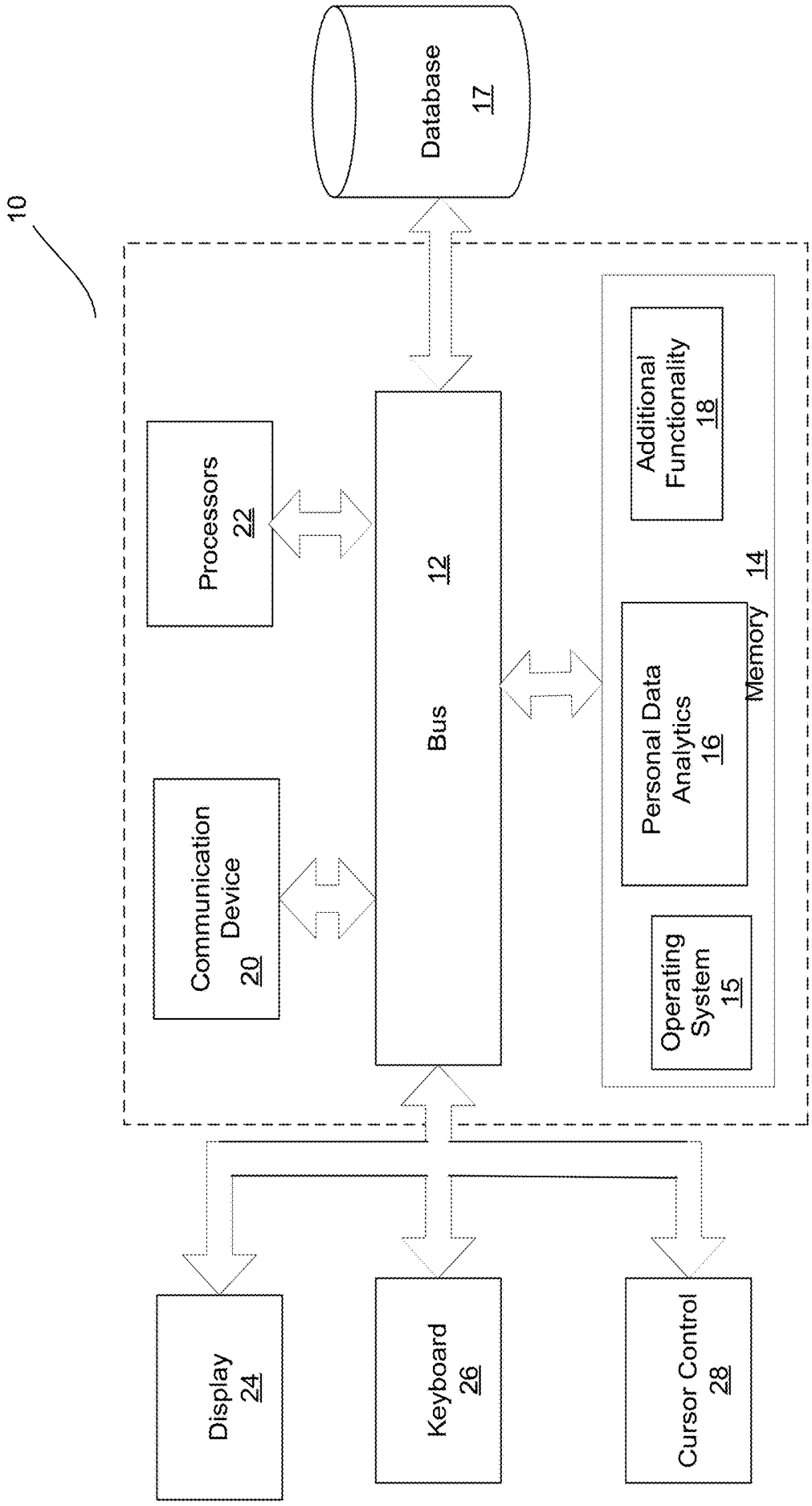

10
Database
17
Processors
22
Bus
12
Additional
Functionality
18
Memory
14
Personal Data
Analytics
16
Operating
System
15
Communication
Device
20
Display
24
Keyboard
26
Cursor Control
28

Fig. 8

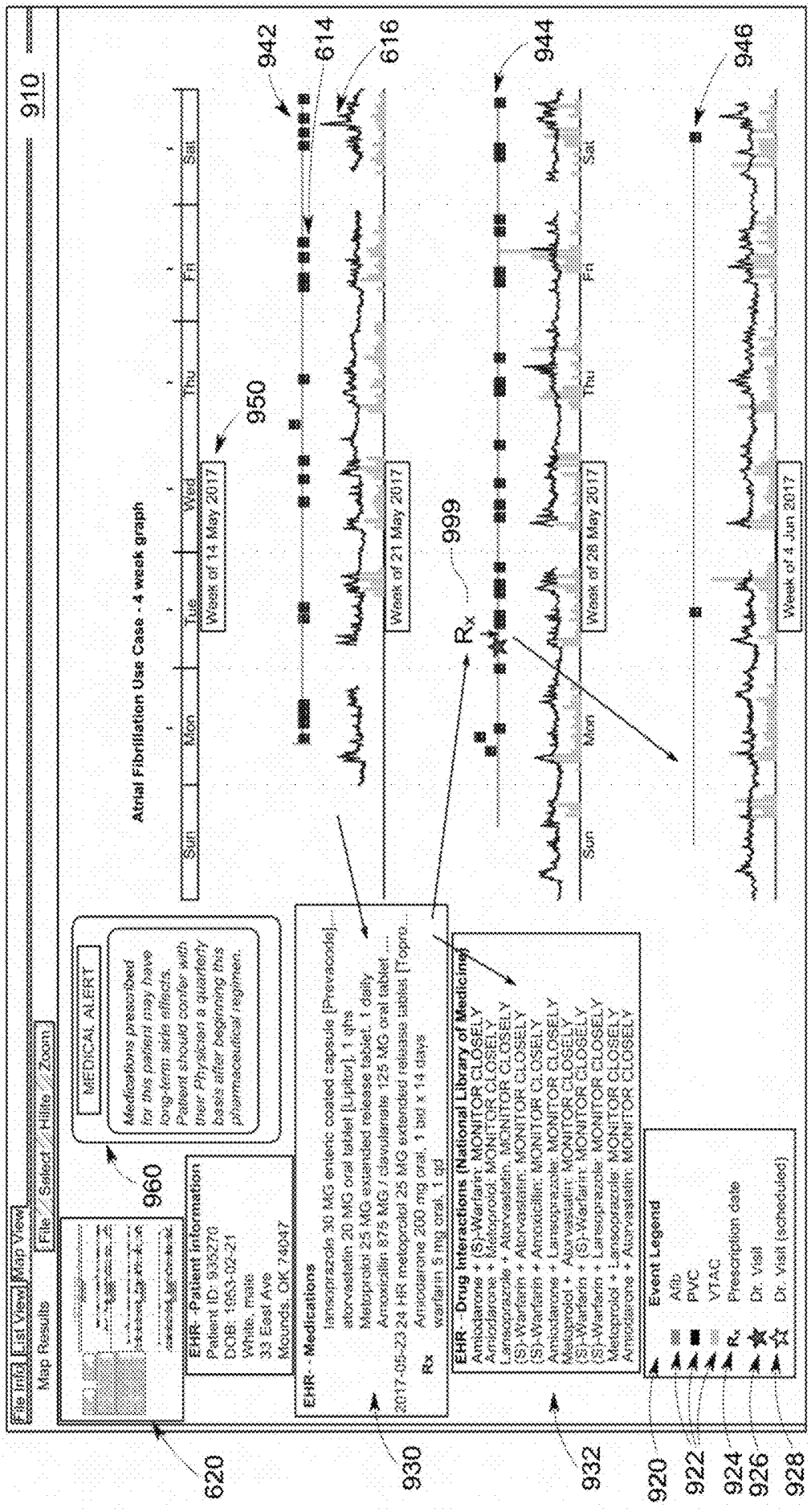

910
File Info
List View
Map View
Map Results
File / Select / Hilite / Zoom
960
MEDICAL ALERT
Medications prescribed for this patient may have long-term side effects. Patient should confer with their Physician a quarterly basis after beginning this pharmaceutical regimen.
EHR - Patient Information
Patient ID: 936270
DOB: 1953-02-21
White, male
33 East Ave
Mounds, OK 74047
EHR - Medications
lansoprazole 30 MG enteric coated capsule [Prevacid]...
atorvastatin 20 MG oral tablet [Lipitor], 1 qhs
Metoprolol 25 MG extended release tablet, 1 daily
Amiodarin 875 MG / clavulanate 125 MG oral tablet ...
2017-05-23 24 HR metoprolol 25 MG extended release tablet [Toprol...
Rx
Amiodarone 200 mg oral, 1 tad x 14 days
warfarin 5 mg oral, 1 qd
EHR - Drug Interactions (National Library of Medicine)
Amiodarone + (S)-Warfarin: MONITOR CLOSELY
Amiodarone + Metoprolol: MONITOR CLOSELY
Lansoprazole + Atorvastatin: MONITOR CLOSELY
(S)-Warfarin + Atorvastatin: MONITOR CLOSELY
(S)-Warfarin + Amiodarone: MONITOR CLOSELY
Amiodarone + Lansoprazole: MONITOR CLOSELY
Metoprolol + Atorvastatin: MONITOR CLOSELY
(S)-Warfarin + (S)-Warfarin: MONITOR CLOSELY
(S)-Warfarin + Lansoprazole: MONITOR CLOSELY
Metoprolol + Lansoprazole: MONITOR CLOSELY
Amiodarone + Atorvastatin: MONITOR CLOSELY
Event Legend
Afib
PVC
VTAC
Prescription date
Dr. Visit
Dr. Visit (scheduled)
Atrial Fibrillation Use Case - 4 week graph
Sun
Mon
Tue
Wed
Thu
Fri
Sat
Week of 14 May 2017
Week of 21 May 2017
Week of 28 May 2017
Week of 4 Jun 2017
950
942
614
616
944
946
999
Rx
620
930
932
920
922
924
926
928

FIG. 9

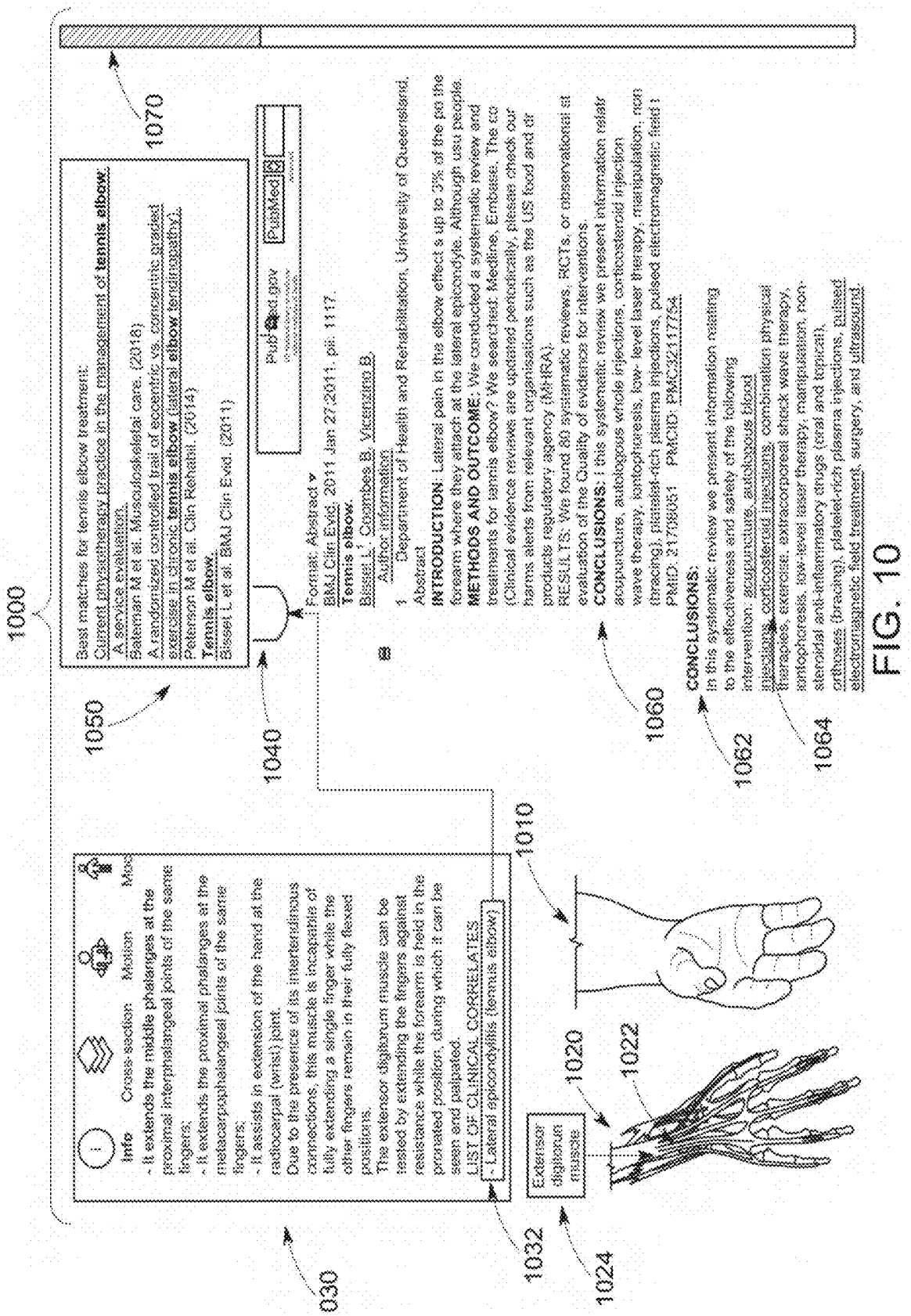

1000
1010
1020
1022
1024
1030
1032
1040
1050
1060
1062
1064
1070
Info
Cross-section
Motion
Muscle
- It extends the middle phalanges at the proximal interphalangeal joints of the same fingers.
- It extends the proximal phalanges at the metacarpophalangeal joints of the same fingers.
- It assists in extension of the hand at the radiocarpal (wrist) joint.
Due to the presence of its interdigitous connections, this muscle is incapable of fully extending a single finger while the other fingers remain in their fully flexed positions.
The extensor digitorum muscle can be tested by extending the fingers against resistance while the forearm is held in the pronated position, during which it can be seen and palpated.
LIST OF CLINICAL CORRELATES
- Lateral epicondylitis (tennis elbow)
Extensor digitorum muscle
Best matches for tennis elbow treatment:
Current physiotherapy practice in the management of tennis elbow.
A service evaluation.
Bateman M et al. Musculoskeletal care. (2018)
A randomized controlled trial of eccentric vs. concentric graded exercise in chronic tennis elbow (lateral elbow tendinopathy).
Peterson M et al. Clin Rehabil. (2014)
Tennis elbow.
Bissel L et al. BMJ Clin Evid. (2011)
PubMed.gov
PubMed
Format: Abstract
BMJ Clin Evid. 2011 Jan 27;2011. pii: 1117.
Tennis elbow.
Bissel L, Coombes B, Vicenzino B.
Author information
1 Department of Health and Rehabilitation, University of Queensland.
Abstract
INTRODUCTION: Lateral pain in the elbow effect s up to 3% of the po the forearm where they attach at the lateral epicondyle. Although usu people.
METHODS AND OUTCOME: We conducted a systematic review and treatments for tennis elbow? We searched: Medline, Embase, The co (Clinical evidence reviews are updated periodically, please check our harms alerts from relevant organisations such as the US food and dr products regulatory agency (MHRA).
RESULTS: We found 80 systematic reviews, RCTs, or observational st evaluation of the Quality of evidence for interventions.
CONCLUSIONS: I this systematic review we present information relati acupuncture, autologous whole injections, corticosteroid injection wave therapy, iontophoresis, low- level laser therapy, manipulation, non (bracing), platelet-rich plasma injections, pulsed electromagnetic field t
PMID: 21706051 PMCID: PMC3211754
CONCLUSIONS:
In this systematic review we present information relating to the effectiveness and safety of the following intervention: acupuncture, autologous blood injections, corticosteroid injections, combination physical therapies, exercise, extracorporeal shock wave therapy, iontophoresis, low-level laser therapy, manipulation, non steroidal anti-inflammatory drugs (oral and topical), orthoses (bracing), platelet-rich plasma injections, pulsed electromagnetic field treatment, surgery, and ultrasound.

FIG. 10

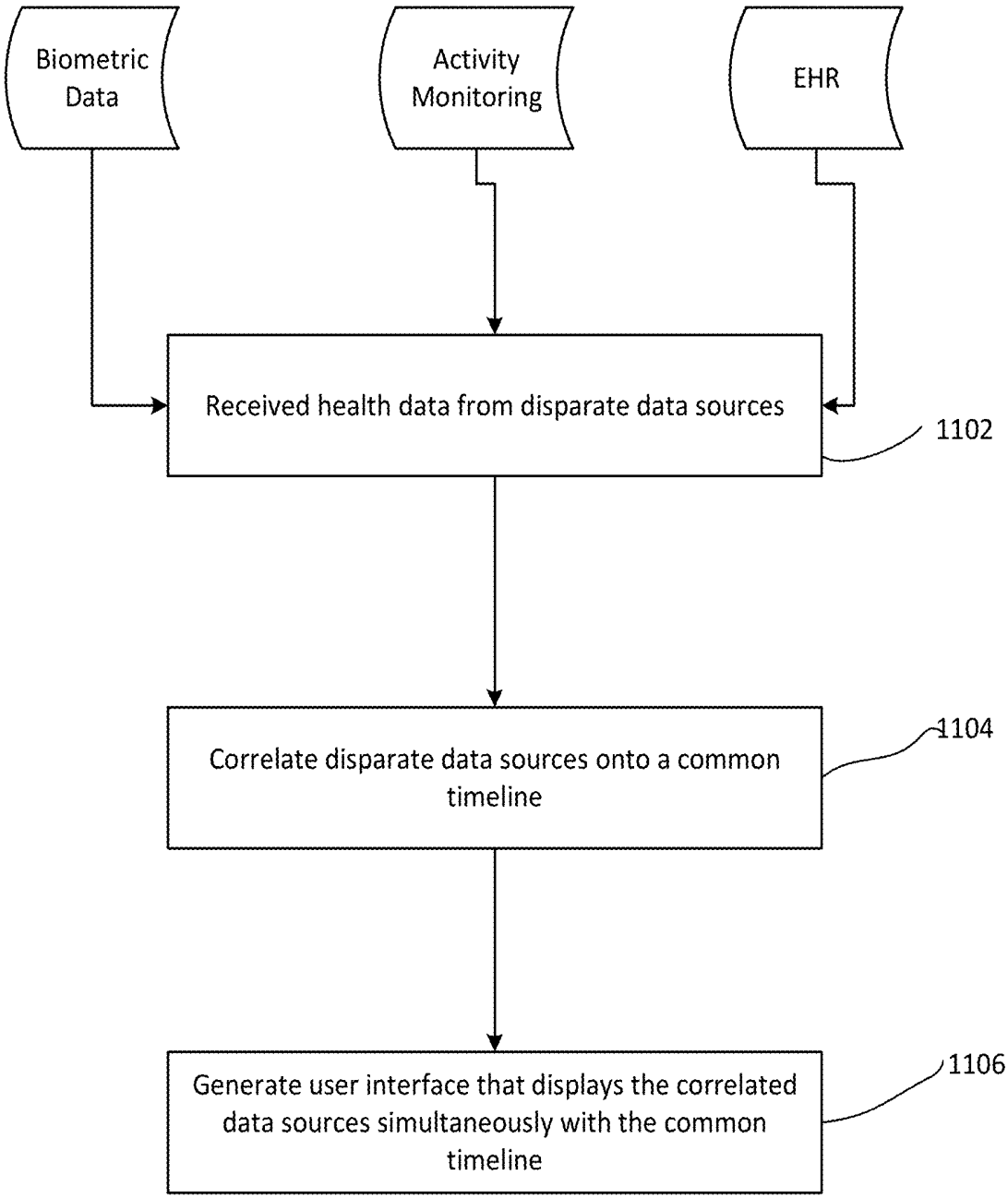

Biometric Data
Activity Monitoring
EHR
Received health data from disparate data sources
1102
Correlate disparate data sources onto a common timeline
1104
Generate user interface that displays the correlated data sources simultaneously with the common timeline
1106

Fig. 11

PERSONAL DATA ANALYTICS SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application Ser. No. 62/769,975, filed on Nov. 20, 2018, disclosure of which is hereby incorporated by reference.

FIELD

[0002] Example inventions are directed generally to a computer system, and in particular to a computer system for monitoring biometric data and correlating the biometric data with health-related information for analytics.

BACKGROUND INFORMATION

[0003] There has recently been a proliferation of devices, many that are wearable, that generate health-related data, including biometric data, for the user. For example, devices track a user's heartbeat, blood pressure, number of steps taken or other activity, electrocardiogram ("EKG") information, etc. However, in general, this health data, when it comes from separate disparate devices or other sources, has not easily been aggregated in a way to be useful to a user and/or health provider.

[0004] Generally, there is a need to have the ability to view health history data and how it correlates to other information in the health field, with the goal of modifying an individual's behaviors to improve his or her health, or the health of a person under his or her care. Users may include entities in a variety of situations seeking to view individuals' health data and correlate that data to other information, such as a person viewing and correlating their own health data to their health history and to aggregated health data across a population, and medical professionals, such as doctors, nurses, caregivers, hospitals; researchers in academia, government, industry and insurers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. **1** illustrates a personal data analytics system in accordance with example inventions.

[0006] FIG. **2** illustrates a personal data analytics system in accordance with example inventions.

[0007] FIG. **3** illustrates a personal data analytics system in accordance with example inventions.

[0008] FIG. **4** illustrates a personal data analytics system in accordance with example inventions.

[0009] FIG. **5** is a flowchart of reporting functionality in accordance with example inventions.

[0010] FIG. **6**A is a user interface ("UI") for displaying generated information in accordance to example inventions.

[0011] FIG. **6**B is a UI for displaying generated information in accordance to example inventions.

[0012] FIG. **7** illustrates an overall system that combines data sources and performs data analysis in accordance to example inventions.

[0013] FIG. **8** is a block diagram of a computer server/system in accordance with examples of the present invention.

[0014] FIG. **9** is a UI for displaying generated information, including correlations and alerts, in accordance to example inventions.

[0015] FIG. **10** is a UI for displaying generated information in accordance to example inventions.

[0016] FIG. **11** is a flow diagram of the personal data analytics module of FIG. **8** when generating personal data analytics in accordance to example embodiments.

DETAILED DESCRIPTION

[0017] An individual/user has a need to learn how their health can be improved by monitoring their own biometric data over time, and how the biometric data correlates to pharmaceutical, medical, and other data specifics contained in the person's health record, and how the data correlates to larger data sets from populations. Examples of the invention are directed to displaying a user's health data across a span of time, (referred to as "Biometric Monitoring" data), with markers to indicate how variations in the health data correlate to specifics from a wider range of data sets, such as pharmaceutical data, medical diagnostic data, or a user's own life data (referred to as a "user health record"). Further, example inventions generate a user interface that displays the disparate sources of information onto a common timeline, which generates and facilitates further analytics regarding the combination of information.

[0018] There is further a need for correlation of disparate data sources when a person or organization wants to learn how an individual's or a group's health can be improved. Factors that promote health improvement can be assessed by correlating collected health data with larger data sets, including displaying the disparate data along a common timeline. This information can be used to guide therapies and healthy behaviors. The present invention is directed to a system and method to display a user's health data across a span of time and a common timeline with other information, as described above. Example inventions may also be used to display health data for an individual or aggregate data across a population of individuals.

[0019] FIG. **1** illustrates a personal data analytics system in accordance with example inventions. In FIG. **1**, one or more health devices **110** monitor a user **120** and collects user biometric data **130**, which is sent to a user data store or database **140**. Data store **140** also collects data from one or more user monitoring devices **150**, such as a Global Positioning System ("GPS") device **152**, a camera **154** and a smartphone **156**. Health devices **110** may include electrocardiogram ("ECG") monitors, electroencephalogram ("EEG") monitors, fitness devices, blood pressure monitors, activity monitors, etc.

[0020] In some examples, health devices **110** include one or more smart patches **124** worn by user **120**. In examples, a "smart" patch **124** is attached to the medial malleolus of user **120** on the right or left ankle of user **120** in accordance to examples.

[0021] The placement of each patch **124** is designed to cause electrical stimuli to activate the tibial nerve of user **120** in one example to alleviate overactive bladder ("OAB") symptoms. The term "smart", in general, refers to the use of memory and logic components and instructions, and may also include electronic components for communications, to generate some or all of the functionality disclosed herein.

[0022] Patch **124** can be any type of device that can be fixedly attached to user **120** and includes a processor/controller and instructions that are executed by the processor, or a hardware implementation without software instructions, and communication elements to provide

communications with a controller (e.g., smartphone **156** or a fob) in some examples. Patch **124** can also include additional components that provide topical nerve stimulation on user **120** to provide benefits to user **120**, including bladder management for an overactive bladder, such as electrodes, sensors, a battery, adhesive, a control unit, an electronic integrated package, stimulators, etc.

[0023] Patch **124** in one example can include a flexible substrate, a malleable dermis conforming bottom surface of the substrate including adhesive and adapted to contact the dermis, a flexible top outer surface of the substrate approximately parallel to the bottom surface, one or more electrodes positioned on the patch proximal to the bottom surface and located beneath the top outer surface and directly contacting the flexible substrate, electronic circuitry embedded in the patch and located beneath the top outer surface and integrated as a system on a chip that is directly contacting the flexible substrate, the electronic circuitry integrated as the system on the chip and including an electrical signal generator integral to the malleable dermis conforming bottom surface configured to electrically activate the one or more electrodes, a signal activator coupled to the electrical signal generator, a nerve stimulation sensor that provides feedback in response to a stimulation of one or more nerves, an antenna configured to communicate with a remote activation device, a power source in electrical communication with the electrical signal generator, and the signal activator, where the signal activator is configured to activate in response to receipt of a communication with the activation device by the antenna and the electrical signal generator configured to generate one or more electrical stimuli in response to activation by the signal activator, and the electrical stimuli configured to activate/stimulate one or more nerves of a user wearing patch **124** at least at one location proximate to patch **124**. Additional details of examples of patch **124** are disclosed in U.S. Pat. No. 10,016,600, entitled "Topical Neurological Stimulation", the disclosure of which is hereby incorporated by reference.

[0024] In some examples, health monitoring devices **110**, such as patch **124**, can send and receive data from a controller, and send the data on to a cloud service. In some examples, patch **124** stimulates the tibial nerve of user **120** at the direction of a doctor/caregiver via direct or remote activation to elicit a suppressive nerve response, which, in turn, suppresses the urination impulse.

[0025] In some examples, the system measures the state of the patient's bladder to determine the degree of urgency in voiding the bladder. In some examples, the system uses ultrasound to measure the state of the bladder.

[0026] In some examples, the system may measure other biometric attributes of user **120** to determine the degree of urgency in voiding the bladder. Examples of these measurements may be a clenching of abdominal muscles, or restlessness during sleep, or the shape or opacity of the bladder when imaged.

[0027] Biometrics refers to body measurements and calculations and metrics related to human characteristics. Biometric identifiers are the distinctive, measurable characteristics used to label and describe individuals and include physiological and behavioral characteristics. Physiological characteristics are related to the shape of the body. Examples include veins, face recognition, DNA, palm print, hand geometry, iris recognition, retina and odor/scent. Behavioral characteristics are related to the pattern of behavior of a person, including typing rhythm, gait, and voice.

[0028] In some examples, health monitoring devices **110** include a device for determining when an OAB event has occurred. For example, a moisture detection element in a smart diaper or other garment worn by user **120** can perform analysis to determine an OAB event, and the time of the event, and output this data to the system. In another example, the monitoring of the instances that patch **124** is activated by the user to stimulate the nerves provides an indication of an increase or decrease of OAB conditions and the urge to urinate.

[0029] FIG. **2** illustrates a personal data analytics system in accordance with example inventions. In FIG. **2**, user data stores **140** provides user data **210** to one or more processors/servers **220**. Processor **220** further accesses at least one of a user health record database **230**, a drug database **240**, a population database **250**, or a genetic database **260**. Processor **220** analyzes these data sources to create at least one of a user report **270**, a professional report **272**, or a caregiver report **274**.

[0030] FIG. **3** illustrates a personal data analytics system in accordance with example inventions. In FIG. **3**, individual access processes are shown as interfaces between the data stores of FIG. **2** and processor **220**. User health record database **230** is accessed through an UHR API **330**, making specific user health record data available in a format understandable to processor **220**. Similarly, drug database **240** is accessed through a Drug DB API **340**; population database **250** is accessed through a Population DB API **350**; genetic database **260** is accessed through a Genetic DB API **360**; and accesses to other data **370** are made through either specific or general APIs **374**. Processor **220** correlates these data streams using a correlation engine **380**, which is provided with access to a medical analysis database **384**. Correlation engine **380** converts data from various sources into a common format to facilitate data translation and use in analysis and data presentation, including displaying the data on a common timeline. In addition to medical analysis database **384**, processor **220** accepts inputs from professional responses **390**.

[0031] FIG. **4** illustrates a personal data analytics system in accordance with example inventions. In FIG. **4**, professional responses **390** are generated from professional input devices **410**, which are provided with input questionnaire **420**, based on access to processor/server **220**, which feeds data into questionnaire **420**, and with input forms **430**, which medical professionals use to input data for particular medical situations. Professional responses **390** may also occur when the professional, such as a physician, nurse, caregiver, etc., studies the various data sources, either before or after the work of correlation engine **380**.

[0032] FIG. **5** is a flowchart of reporting functionality in accordance with example inventions. FIG. **5** illustrates a process of creating user report **270** using a user report process **520**, and professional report **272** using a professional report process **530**, and caregiver report **274** using a caregiver report process **540**. Each of the processes draws data from the appropriate databases, and outputs a report.

[0033] Referring again to FIG. **1**, recent advances in technology have made available to users a variety of devices and systems that can function as health monitoring devices **110** for measuring one or more biometric data type, such as step count, pulse rate, blood pressure, respiration rate,

hydration, blood sugar levels, body mass index, etc. Many of these devices provide means for displaying the data collected on the device to the user, with the help of a computer and display or on the device itself. In some cases, the data may be displayed as a data series, across a span of time, the time range being part of the display, such as in hours, days, weeks. Some of these display systems may also show limit lines, such as the recommended minimum or maximum value, or both, for the specific biometric parameter being shown, such as maximum or minimum blood pressure or pulse rate.

[0034] The user may discern from the displayed data how his or her health varies across time. This discernment is limited inasmuch as the displayed raw data is not correlated to a variety of underlying mechanisms which affect the user's health. For example, the display of multiple biometric data types, aligned across the time span of the display, may also help the user to understand why their biometric data is varying or is not in the optimum range between recommended minimum and maximum values.

[0035] Example inventions can combine biometric data with other data types, such as electronic health records ("EHR"s), using correlations derived from medical information or from statistical analysis of the data or from machine learning or artificial intelligence analysis or from human analysis. This is the work of correlation engine **380** of FIG. **3**, which may employ one or more of these data analysis techniques.

[0036] A user may better understand the data and glean pertinent information presented in user report **270** because the presentation of the data is designed by user report process **520**. Similarly, professionals may derive more value from the data presented in professional report **272** because the presentation of the data is designed by professional report process **530** and caregivers may better understand and take action from the data presented in caregiver report **274** because of the selected formats and content by caregiver report process **540**.

[0037] Example inventions generate a user interface that combines data from various sources, to assist the various types of users in drawing conclusions from the information. FIG. **6**A is a user interface ("UI") for displaying generated information in accordance to example inventions. The UI of FIG. **6**A includes a user timeline view **610** with timeline labels **612** (i.e., days of the week), event marker icons **614** that indicate OAB events, a line graph trace **616**, a bar chart trace **618**; navigation window **620**; EHR data **630** with EHR event tabular data **632**, EHR prescription data **634**, and lab test tabular data **636**.

[0038] FIG. **6**B is a UI for displaying generated information in accordance to example inventions. The UI of FIG. **6**B includes event marker icons **614** with arrhythmia events; navigation window **620**; EHR data **630** with EHR event tabular data **632**, EHR prescription data **634**, EHR drug interaction data **638**, and EHR vital signs data **639**; user identification data **642**; and a legend **644**.

[0039] The data in the UIs of FIGS. **6**A, **6**B is presented on a user interface as timeline **610**, the scale of which may be changed from daily to weekly to monthly to yearly view **612**, adjusting the level of detail of the user data accordingly. User data is presented according to the type of data, with event data **614** such as OAB/urination events shown as stacked icons; continuous data **616** such as heart rate shown as a continuous line graph; and quantitative, discrete data **618** such as step counts shown as bars along the timeline. Related health data is presented in smaller windows in tabular form **630**, including EHR event tabular data **632**, such as doctor visits; EHR prescription data **634**, such as dosages; EHR lab test tabular data **636**, such as historical blood chemistry measurements; EHR drug interaction data **638**, including warnings; and EHR vital signs data **639**, such as historical blood pressure measurements. The interface is labeled with user identification data **642**. The user navigates the user interface with the navigation window **620**. Legend **644** aids in navigation. On this combined presentation, the viewer may combine historical data with current data and medical reference data such as drug interaction details to provide the user with directives.

[0040] For example, the biometric data showing blood pressure may show a variation with a high value early in each day, excepting Saturdays and Sundays, with a similarly high value late in each weekday. Examples inventions can combine the blood pressure biometric data with a record of the user's movements as collected from their smartphone GPS system on a common timeline, and deduce that the user is moving rapidly during each of the periods when the blood pressure is markedly higher, this movement being further deduced to be in a vehicle. The display of this information across a period of multiple days and weeks, with annotations to highlight the higher blood pressure periods and a note that this is the user's commute time, is all presented to the user on a single UI or printed report. Through the use of example inventions that can include the derivation of a recommendation, the user is able to consider whether to change his or her behavior. In the example, the user may choose to travel to and from work at a different time of day based on the generated data.

[0041] In another example, the user provides a diary which records the meals he or she has had, and the foods consumed. Examples inventions have access to this diary data, as well as to the user's prescription drug history through the user's EHR, and the user's biometric data. The pharmaceutical data for the user is made more useful by examples inventions which can access one or more external drug interactions databases. All of these data sources are analyzed and correlated by examples inventions, across a span of time measurements, and examples inventions deduce that the user occasionally consumes foods which adversely affect the effectiveness of one of the user's prescription medications. Further, example inventions deduce that the user is taking a medication at a time of day when the user is driving a vehicle, this medication being prone to cause drowsiness. The user is informed of these relationships through the use of time series displays on a UI or printed report, or as warnings or alerts such as on a smart phone device. Through these means, delivered by examples inventions, the user is able to change his or her behavior by avoiding certain foods, and avoiding the taking of one of the user's medications during driving times.

[0042] In another example, the user who has been diagnosed with atrial fibrillation ("AFib") is instructed by the user's physician to monitor himself or herself using various data-gathering devices. Examples inventions combine the data from those sources into a form and format useful to the medical professional to make further determination for the user, such as modifying the prescription instructions for a particular medication, or limiting user's activities in areas which may aggravate the user's AFib condition, or relaxing

restrictions or medications if example inventions reveal that the condition is less serious than was initially diagnosed. The process between the user and the medical professional may proceed as follows: (a) the user reports symptoms to primary care physician ("PCP"): fatigue, light-headedness, reduced ability to exercise; (b) the PCP records an ECG during office visit, and periods of AF are detected, so that the PCP refers the user to a Cardiologist; (c) the Cardiologist has the user wear an ECG monitoring device for a 2-week period to measure baseline AFib burden (% of time in AFib), and has the user also wear a FitBit or similar device to measure physical activity; (d) at a Cardiologist follow up visit, a review of the ECG data reveals overall AFib burden of 21%, such that the Cardiologist prescribes Amiodarone, an anti-arrhythmic medication, along with Warfarin, anti-coagulant, to reduce risk of embolic stroke; (e) the user continues to wear the ECG patch and the FitBit type of device for another 2-week period after starting medication; (f) at a subsequent Cardiologist follow up visit, a review of the ECG and Fitbit type of device data to determine changes in AF burden and physical activity after medication was started reveals that AF burden has been reduced, such that the medication dosages may be adjusted to reduce medication side-effects; and (g) the monitoring process repeated.

[0043] FIG. **7** illustrates an overall system **700** that combines data sources and performs data analysis in accordance to example inventions. System **700** includes a plurality of data sources **701** and a database/analytics **702** functionality. Data sources **701** includes the accumulation of many different data types, all representing data focused about the health parameters of individuals or groups of individuals. The various data types include traditional electronic health records (EHR/MHR) **710** that capture individual health records including doctor/hospital visits, laboratory results, imaging results, medications, insurance records, etc. The data includes whole classes of Internet of Things ("IOT") devices **711**, such as activity monitoring devices, communication devices, wearable devices incorporating sensors and analytics (e.g. the Apple Watch), home monitoring devices (e.g., the "Nest" device), a topical nerve stimulator/sensor (TNSS) family of devices such as patch **124** disclosed above. Data sources **701** include consumer generated data **713** including surveys and social media such as blogs, forums, etc. Data sources **701** further include search data **714** include specific medical databases (e.g., "PubMed", clinical trials, regulatory records, etc.), medical references (e.g., Gray's Anatomy, etc.) and traditional Chinese medicine ("TCM") sources.

[0044] The data is stored in various different data structures **702** and the data from various sources are represented in a Foundation Data Store **721**. The various data types includes both structured data (e.g., EHR, consumer surveys) and real-time signals (e.g., EKG, activity tracking data, etc.).

[0045] In general, examples include two forms of data, those that have been preprocessed and distilled by their sources (e.g., "PubMed" articles, Clinical Trials, etc.) and those that have been minimally processed, or just raw data, and represent the original data captured (e.g., Fitbit data, EEG recordings, PSG data, etc.). Further, there are those data sources that are mixed, having elements of preprocessed data and minimally altered raw data (e.g., EHR). Another dimension is whether the data source originates from many individuals, or from a single individual (e.g., Clinical Trials vs Gray's Anatomy reference online book). Various data storage formats **727-730** are fed into analytics processing **726** to generate data for applications, a user interface, and additional data at **725**.

[0046] In one example, correlation engine **380** unifies these forms of data by treating each as examples of "events" or "snapshots". For example, data that is an EHR represents primarily single event data, such as a doctor visit, a doctor diagnosis, laboratory results or prescribed medications. This event data is characterized by a timestamp (e.g., day of visit, date/time of laboratory tests, etc.). Data from wearable devices are a series of "events" where that series may be hundreds or thousands of sequential events. In a similar manner, each event in the series can be characterized by an individual timestamp.

[0047] FIG. **8** is a block diagram of a computer server/system **10** in accordance with examples of the present invention. Although shown as a single system, the functionality of system **10** can be implemented as a distributed system. Further, the functionality disclosed herein can be implemented on separate servers or devices that may be coupled together over a network. Further, one or more components of system **10** may not be included. For example, for functionality of a server, system **10** may need to include a processor and memory, but may not include one or more of the other components shown in FIG. **8**, such as a keyboard or display. All or portions of system **10** may be used to implement any or all of the components shown in FIGS. **1-4** and **7** in some examples.

[0048] System **10** includes a bus **12** or other communication mechanism for communicating information, and a processor **22** coupled to bus **12** for processing information. Processor **22** may be any type of general or specific purpose processor. System **10** further includes a memory **14** for storing information and instructions to be executed by processor **22**. Memory **14** can be comprised of any combination of random access memory ("RAM"), read only memory ("ROM"), static storage such as a magnetic or optical disk, or any other type of computer readable media. System **10** further includes a communication device **20**, such as a network interface card, to provide access to a network. Therefore, a user may interface with system **10** directly, or remotely through a network, or any other method.

[0049] Computer readable media may be any available media that can be accessed by processor **22** and includes both volatile and nonvolatile media, removable and non-removable media, and communication media. Communication media may include computer readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave or other transport mechanism, and includes any information delivery media.

[0050] Processor **22** is further coupled via bus **12** to a display **24**, such as a Liquid Crystal Display ("LCD"). A keyboard **26** and a cursor control device **28**, such as a computer mouse, are further coupled to bus **12** to enable a user to interface with system **10**.

[0051] In one embodiment, memory **14** stores software modules that provide functionality when executed by processor **22**. The modules include an operating system **15** that provides operating system functionality for system **10**. The modules further include a personal data analytics module **16** that provides personal data analytics functionality, and all other functionality disclosed herein. System **10** can be part of a larger system. Therefore, system **10** can include one or more additional functional modules **18** to include the addi-

tional functionality. A database **17** is coupled to bus **12** to provide centralized storage for modules **16** and **18**. In one embodiment, database **17** is a relational database management system ("RDBMS") that can use Structured Query Language ("SQL") to manage the stored data.

[0052] FIG. **9** is a UI **910** for displaying generated information, including correlations and alerts, in accordance to example inventions. FIG. **9** illustrates how example inventions combine data sources to produce new insights that cause alerts that can change a user's or clinician's behavior. In the example of FIG. **9**, traditional patient EHR data such as doctor's visits and medication lists can be combined with wearable data such as Atrial fibrillation ("AFib") events and EKG signals (measured and recorded by one or more wearables) to develop insights as to appropriate medical interventions.

[0053] In FIG. **9**, a legend **920** is included to assist in interpretation of the cardiac-related events in the user interface. Legend **920** includes unique icons for cardiac events **922**, prescriptions written **924**, doctor visits **926** and scheduled doctor visits **928**. Additional icons are added to legend **920** according to the content of the user interface.

[0054] Multiple biometrics are plotted on a timeline **950** in UI **910**. The scale on timeline **950** is adjustable, to show a span of time varying, for example, from weeks to months to years. UI **910** includes navigation window **620**, and line graph trace **616**. In this example, event marker icons **614** show the series of atrial fibrillation events across week one **942**, week two **944**, and week three **946**. Measurement of atrial fibrillation events during week one **942** resulted in the prescription of medications **930**, which is displayed on a common timeline with the AFib events and the biometric data at **999**. When the user began to take the medications, the frequency of atrial fibrillations was reduced, as shown in week three **946**. Medication interaction analysis **932**, through access to the National Library of Medicine drug interaction database, and other means, is included in UI **910**. Medication interaction analysis **932**, performed by example inventions, has triggered in the system an alert message **960**. Alert message **960** causes a behavior change for the user in scheduling repeated reviews of their prescribed medications, and for the physician in maintaining awareness of possible side effects.

[0055] The data representing AFib could represent multiple patients and not just a single individual. This would be more representative of a clinical study where the medication is a constant variable and the observed reaction of a cohort of patients is the desired result.

[0056] For prescribed medications that should be ingested on a set schedule, the events of taking each medication on a set schedule can be plotted. In one example, the consuming of the medication may be assumed to have taken place on the schedule prescribed by the physician if there is no mechanism for detecting that actual ingesting of the medication. In another example, a system detects or records the taking of the medication, or for physician/nurse administered medicine those events are known, and the events are placed on the timeline. In both examples, correlations may be found between the events of taking medication and the biometrics plotted on the same timeline.

[0057] FIG. **10** is a UI **1000** for displaying generated information in accordance to example inventions. FIG. **10** shows an example of integration and coordination of information from a variety of disparate data sources into a cohesive medical condition user interface **1000**, in this case for lateral epicondylitis. A surface image **1010** is provided, with an anatomical image **1020**, including a target tissue image **1022**, and a target tissue label **1024**, to set the context for the viewer, which may be a user or a medical professional. A target tissue description **1030** is provided by extraction from a medical information database (in this example, "Complete Anatomy", by 3D4Medical, Ltd.), this description including a list of medical conditions **1032** in the target tissue, such as Tennis Elbow. The medical condition is used as a parameter to extract from a research database **1040**, such as "Pubmed", a publication list **1050** pertaining to the medical condition. The publication list is presented in the same user interface with the aforementioned details. When the user selects a publication from publication list **1050**, an abstract **1060** for the selected publication is presented on the same user interface (e.g., in a popup window). The conclusion **1062** is copied from abstract **1060** to facilitate the user's selection of one or more treatment **1064**, several of which are highlighted as hyperlinks. Scroll bars **1070**, or other means, are provided to view content which exceeds the size of the UI **1000** display space.

[0058] The user's selection of a treatment **1064** from UI **1000**, such as that shown in FIG. **10**, may in turn present new surface images **1010** or anatomical images **1020**, or both.

[0059] As disclosed, combining activity data with EHR data can influence medications and/or dosage levels, similar to a drug interaction database that now includes the addition of the analysis of an individual's activity to check against appropriate drug prescriptions. For example, an excessive heart rate during mild exercise may indicate that the dosage level of the individual's heart medication may need to be adjusted. As another example, patch **124** may detect an unsafe increase in urinary urgency following the new prescription of a diuretic drug, which leads to a recommendation that the drug needs to be discontinued.

[0060] Further, placing hyperlinked clinical references on anatomical images representing various medical indications allows clinicians to provide better diagnostic capabilities. Further, combining clinical data with patient data can provide an assessment of the commercial viability of new medical interventions. For example, in the search for new drugs, devices, or interventions, example inventions provide insights into breakthrough clinical results. This will inform business decisions, research funding, and the future paths that clinicians will pursue in their work. Further, embodiments may use the data to classify a user's medical concerns/conditions in order to initiate some type of advertising to the user based on the conditions.

[0061] FIG. **11** is a flow diagram of the personal data analytics module **16** of FIG. **8** when generating personal data analytics in accordance to example embodiments. In one example, the functionality of the flow diagram of FIG. **11** is implemented by software stored in memory or other computer readable or tangible medium, and executed by a processor. In other examples, the functionality may be performed by hardware, for example through the use of an application specific integrated circuit ("ASIC"), a programmable gate array ("PGA"), a field programmable gate array ("FPGA"), etc., or any combination of hardware and software.

[0062] At **1102**, health data is received from disparate data sources, including two or more of biometric data, activity monitoring, or an electronic health record.

[0063] At **1104**, the disparate data sources are correlated onto a common timeline.

[0064] At **1106**, a user interface is generated that displays the correlated data sources simultaneously with the common timeline.

[0065] Several example inventions are specifically illustrated and/or described herein. However, it will be appreciated that modifications and variations of the disclosed example inventions are covered by the above teachings and within the purview of the appended claims without departing from the spirit and intended scope of the invention.

What is claimed is:

1. A method of evaluating a health of a user, the method comprising:

receiving, from a plurality of disparate data sources, health data corresponding to the user, the plurality of disparate data sources comprising two or more of biometric data, activity monitoring, or an electronic health record;

correlating the disparate data sources onto a common timeline; and

generating a user interface that displays the correlated data sources simultaneously with the common timeline.

2. The method of claim **1**, the correlating comprising generating events from the data sources and generating a corresponding timestamp for each event, the electronic health record generating one or more single events and the activity monitoring generating a series of events.

3. The method of claim **1**, further comprising generating events from the data sources, the user interface comprising an icon on the common timeline corresponding to single events, a continuous line graph on the common timeline corresponding to continuous events, and a bar chart on the common timeline corresponding to discrete data.

4. The method of claim **1**, further comprising one or more alerts in response to the correlating.

5. The method of claim **2**, the electronic health record comprising doctor visits, medicine prescribed, medical images and laboratory tests.

6. The method of claim **1**, the activity monitoring generated by a smart patch comprising:

a flexible substrate comprising adhesive on a first side adapted to adhere to a dermis of the user;

an electronic package directly coupled to the substrate, the electronic package comprising a control unit and one or more stimulators; and

electrodes directly coupled to the substrate and the electronic package and disposed between the adhesive and the dermis.

7. The method of claim **1**, the biometric data comprising one or more of a step count, pulse rate, blood pressure, respiration rate, hydration, blood sugar levels or body mass index.

8. The method of claim **4**, the alerts comprising a revision of medication levels.

9. The method of claim **1**, the correlation further comprising a determination of a medical condition.

10. The method of claim **9**, the user interface further comprising displaying an anatomical image that corresponds to the medical condition.

11. A non-transitory computer-readable medium storing instructions which, when executed by at least one of a plurality of processors, cause the processor to evaluate a health of a user, the evaluating comprising:

receiving, from a plurality of disparate data sources, health data corresponding to the user, the plurality of disparate data sources comprising two or more of biometric data, activity monitoring, or an electronic health record;

correlating the disparate data sources onto a common timeline; and

generating a user interface that displays the correlated data sources simultaneously with the common timeline.

12. The computer-readable medium of claim **11**, the correlating comprising generating events from the data sources and generating a corresponding timestamp for each event, the electronic health record generating one or more single events and the activity monitoring generating a series of events.

13. The computer-readable medium of claim **11**, the evaluating further comprising generating events from the data sources, the user interface comprising an icon on the common timeline corresponding to single events, a continuous line graph on the common timeline corresponding to continuous events, and a bar chart on the common timeline corresponding to discrete data.

14. The computer-readable medium of claim **11**, the evaluating further comprising one or more alerts in response to the correlating.

15. The computer-readable medium of claim **14**, the electronic health record comprising doctor visits, medicine prescribed, medical images and laboratory tests.

16. A personal data analytics system comprising:

a plurality of disparate data sources configured to provide health data corresponding to the user, the plurality of disparate data sources comprising two or more of biometric data, activity monitoring, or an electronic health record;

a correlation engine coupled to the plurality of data sources and configured to correlate the disparate data sources onto a common timeline; and

a user interface configured to display the correlated data sources simultaneously with the common timeline.

17. The personal data analytics system of claim **16**, the correlate comprising generating events from the data sources and generating a corresponding timestamp for each event, the electronic health record generating one or more single events and the activity monitoring generating a series of events.

18. The personal data analytics system of claim **16**, the correlation engine further configured to generate events from the data sources, the user interface comprising an icon on the common timeline corresponding to single events, a continuous line graph on the common timeline corresponding to continuous events, and a bar chart on the common timeline corresponding to discrete data.

19. The personal data analytics system of claim **16**, the activity monitoring generated by a smart patch comprising:

a flexible substrate comprising adhesive on a first side adapted to adhere to a dermis of the user;

an electronic package directly coupled to the substrate, the electronic package comprising a control unit and one or more stimulators; and

electrodes directly coupled to the substrate and the electronic package and disposed between the adhesive and the dermis.

20. The personal data analytics system of claim **16**, the biometric data comprising one or more of a step count, pulse rate, blood pressure, respiration rate, hydration, blood sugar levels or body mass index.

* * * * *

专利名称(译)	个人数据分析系统		
公开(公告)号	US20200161001A1	公开(公告)日	2020-05-21
申请号	US16/689577	申请日	2019-11-20
[标]发明人	TOONG HOO MIN D ALBRECHT PAUL GRIMSHAW PAUL E ZHANG TIEJUN		
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IPC分类号	G16H50/30 G16H10/60 A61B5/00		
CPC分类号	A61B5/6833 G16H50/30 G16H10/60 A61B5/746 A61B5/7282 A61B5/7435 G16H40/63 G16H40/67 G16H50/20		
优先权	62/769975 2018-11-20 US		
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摘要(译)

示例发明评估用户的健康。 示例性发明从多个不同的数据源接收与用户相对应的健康数据，该多个不同的数据源包括两个或多个生物统计数据，活动监测或电子健康记录。 示例发明将不同的数据源关联到共同的时间线上。 示例发明产生了用户界面，该用户界面与公共时间线同时显示相关数据源。