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(54) SYSTEMS AND METHODS FOR ADAPTIVE MEDICAL DECISION SUPPORT

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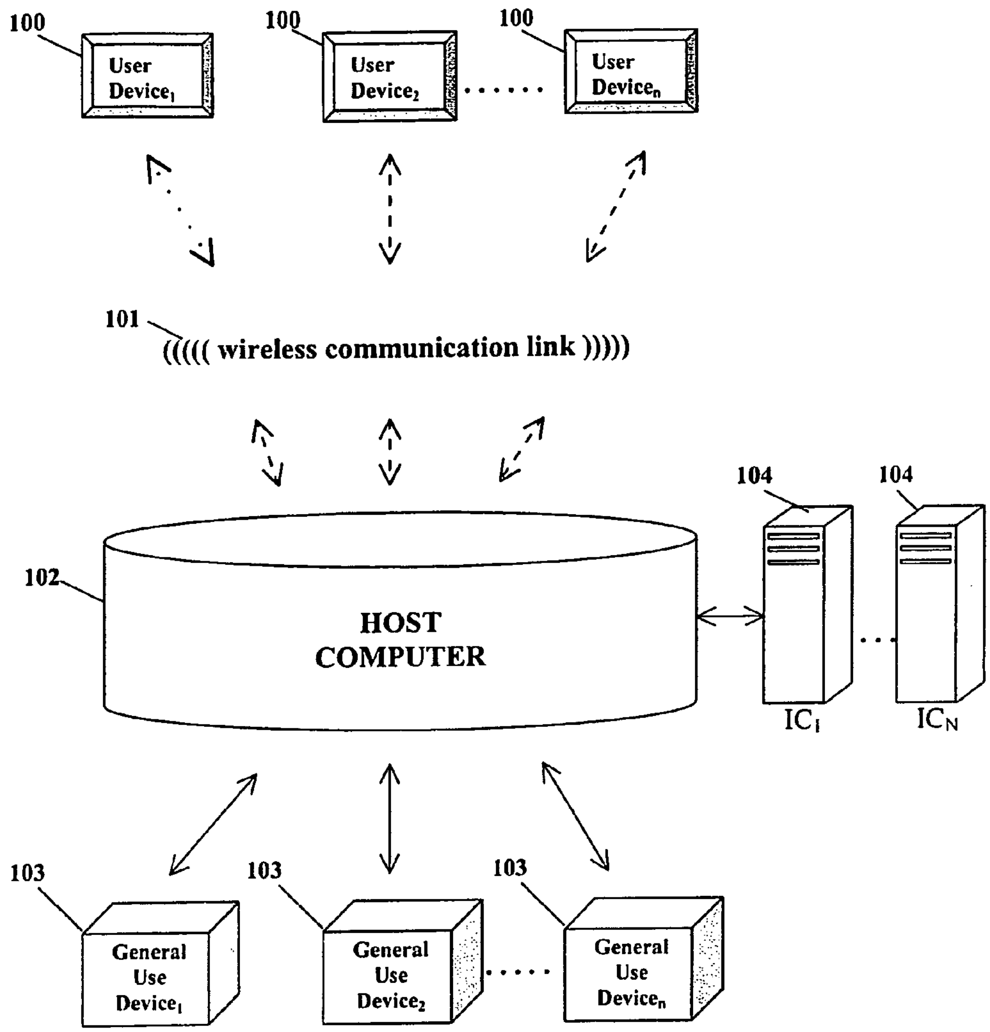
(57) ABSTRACT

A computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving a first input from a first device, receiving a second input from a second device, determining a suggested medical decision based at least in part on the first input and the second input, and transferring the suggested medical decision to the second device.



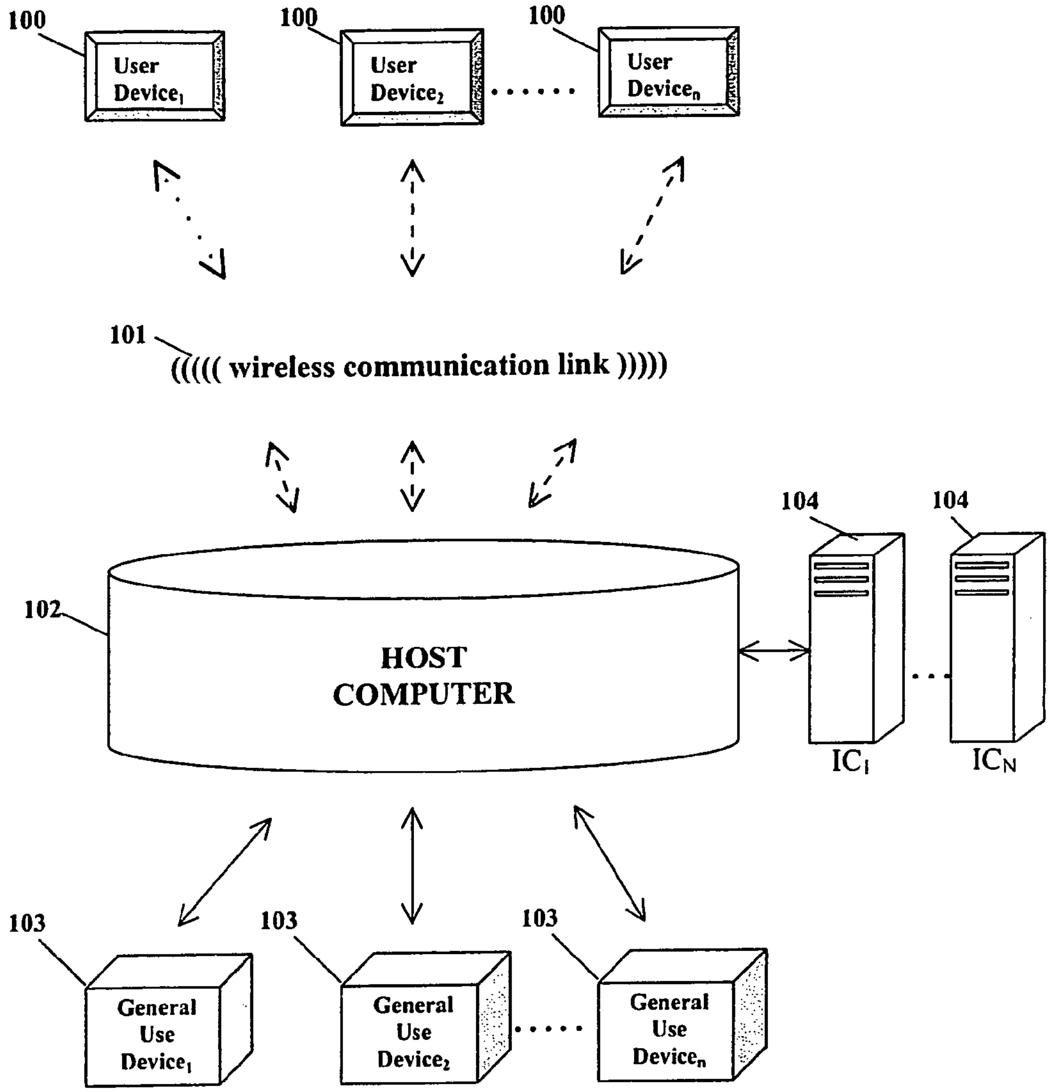

100
User Device1
100
User Device2
100
User Devicen
101
(((((wireless communication link)))))
104
104
102
HOST COMPUTER
IC1
ICN
103
General Use Device1
103
General Use Device2
103
General Use Devicen

FIG. 1

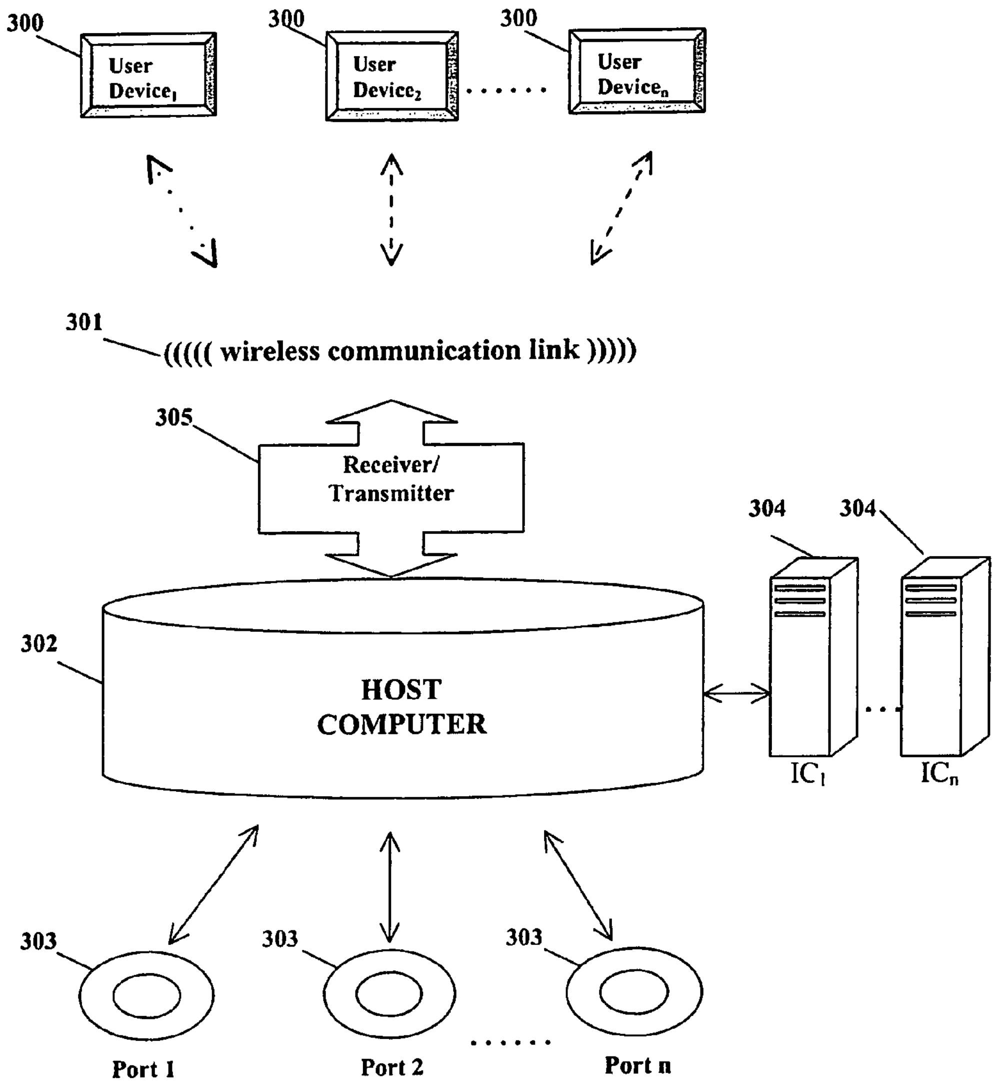

300
User Device$_1$
300
User Device$_2$
300
User Device$_n$
301
(((((wireless communication link)))))
305
Receiver/ Transmitter
304
304
302
HOST COMPUTER
IC$_1$
IC$_n$
303
303
303
Port 1
Port 2
Port n

FIG. 2

400

401 402

EXAMPLES OF INFORMATION TRANSMITTED BY USER TO HOST COMPUTER	
PATIENT DATA	CLINICAL DATA
1) Name | Address |Phone No. 2) Social Security No. | Birthdate 3) Race/Ethnicity 4) Medical History (e.g., prior illnesses, recent preventative tests/results, prior medical procedures/results, prior vaccinations, congenital defects) 5) Allergies 6) Habits (e.g., smoking, toxic exposure, drugs/alcohol) 7) Current and Prior Medications 8) Emergency Contact Information 9) Insurance Information 10) Employment Information	1) Vital Information (e.g., height, weight, temperature, blood pressure) 2) Chief Complaint(s) 3) Other Complaint(s) 4) Physical Examination Findings 5) Patient Answers to Diagnostic Questions 6) Laboratory Orders and Results 7) Diagnoses 8) Treatment Orders 9) Prescription and Pharmacy Information and Instructions 10) Date of Visit and Follow-Up Recommendations 11) Physician/Nurse/Med Tech/P.A. ID Information 12) Billing and Coding Decisions

FIG. 3

500

EXAMPLES OF INFORMATION OUTPUT TO USER BY HOST COMPUTER

1) <u>Patient Assessment Information</u>

Recommendations for questions, physical examination, and medical tests (bloodwork, imaging, etc.).

Patient medical history data.

Name and comments from any referring physician(s).

Common oversights that may be checked at physician discretion.

Pertinent medical information, such as journal articles and the like.

2) <u>Diagnosis Information</u>

Names and descriptions of one or more alternative potential diagnoses.

Recommendations for additional data (e.g., pertinent negatives) that would exclude some potential diagnoses.

Pertinent medical information, such as journal articles and the like.

3) <u>Treatment Order Information</u>

Alternative recommendations for medication types and brands.

Alternative recommendations for surgical or non-surgical procedures.

Alternative recommendations for behavior (bedrest) or diet modifications.

Pertinent medical information, such as journal articles and the like.

4) <u>Virtual Specialist Information</u>

Data pertinent to specific ailment or injury.

Probability of certain actions or recommendations that would be given by specialist.

"Meantime care" – sufficient care until in-person consultation with specialist can be done.

Administrative Specialists such as billing and coding specialists.

FIG. 4

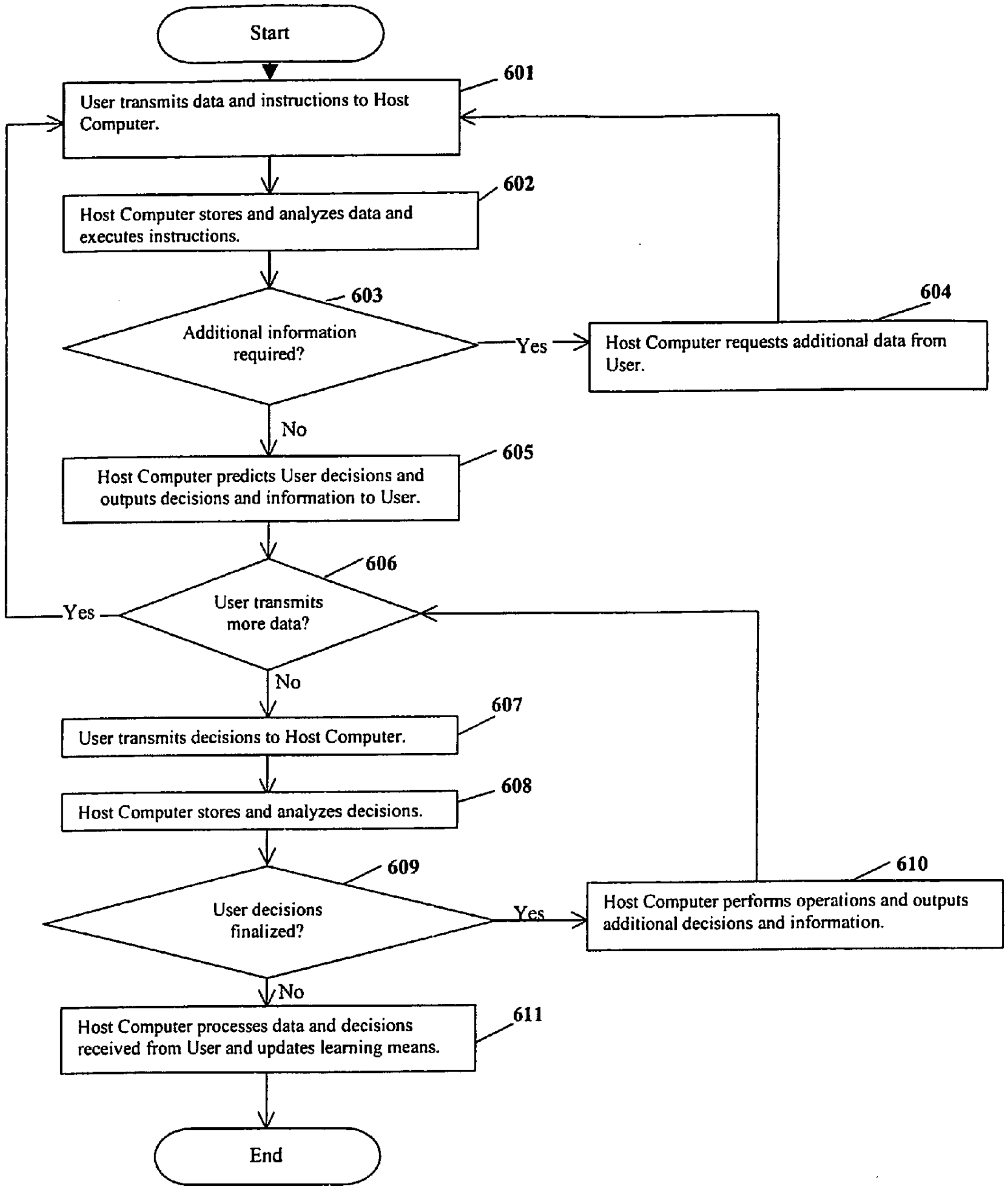

Start
601
User transmits data and instructions to Host Computer.
602
Host Computer stores and analyzes data and executes instructions.
603
Additional information required?
Yes
604
Host Computer requests additional data from User.
No
605
Host Computer predicts User decisions and outputs decisions and information to User.
606
User transmits more data?
Yes
No
607
User transmits decisions to Host Computer.
608
Host Computer stores and analyzes decisions.
609
User decisions finalized?
Yes
610
Host Computer performs operations and outputs additional decisions and information.
No
611
Host Computer processes data and decisions received from User and updates learning means.
End

FIG. 5

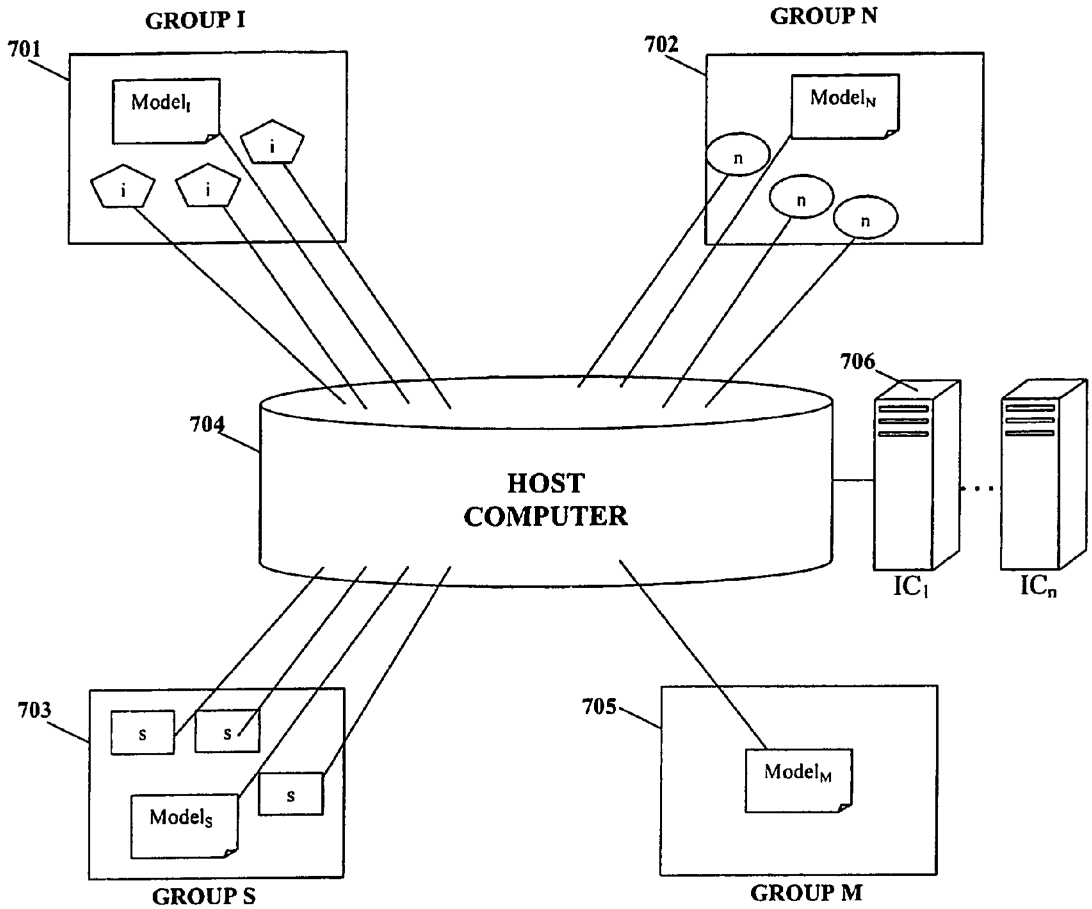

GROUP I
701
Model$_I$
i
i
i
GROUP N
702
Model$_N$
n
n
n
706
704
HOST COMPUTER
IC$_1$
IC$_n$
703
s
s
Model$_S$
s
GROUP S
705
Model$_M$
GROUP M

FIG. 6

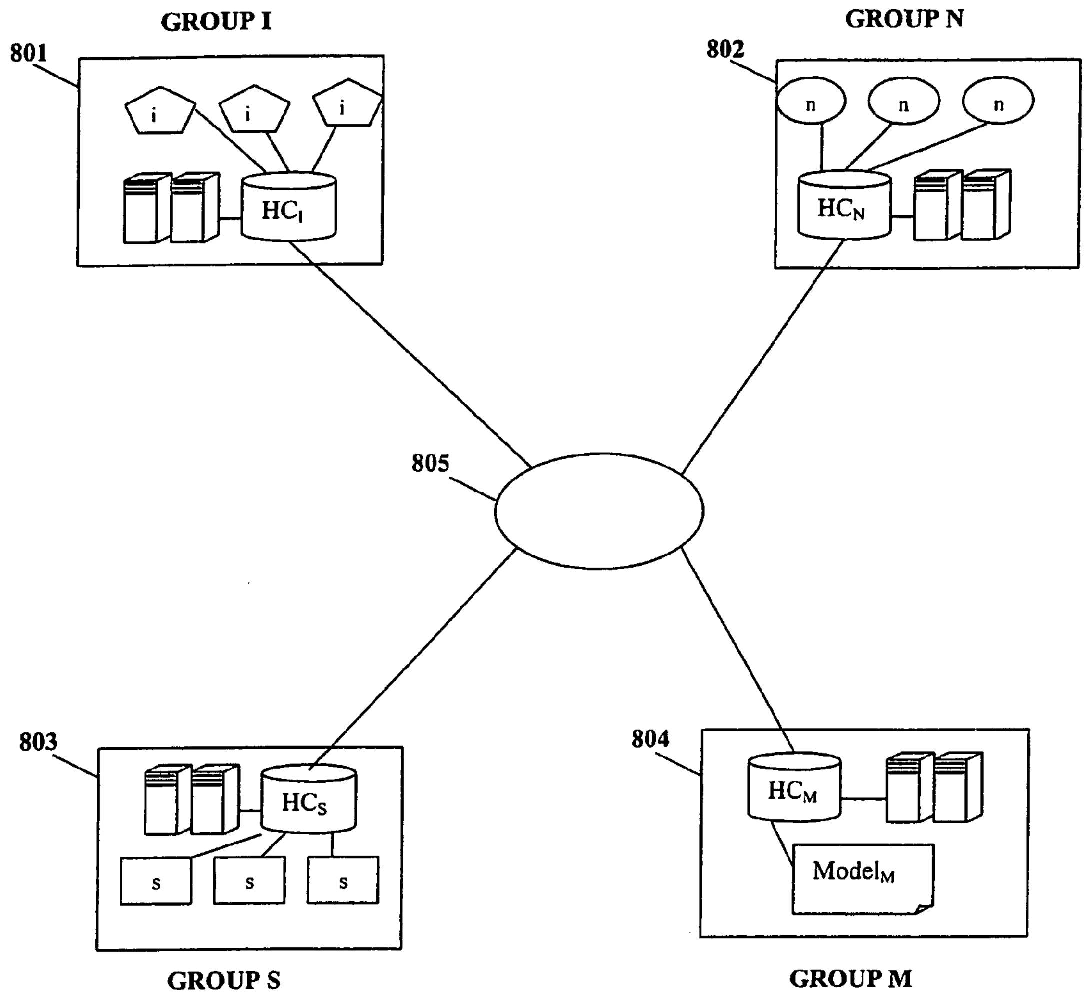

GROUP I
801
i
i
i
HC_I
GROUP N
802
n
n
n
HC_N
805
803
HC_S
s
s
s
GROUP S
804
HC_M
$Model_M$
GROUP M

FIG. 7

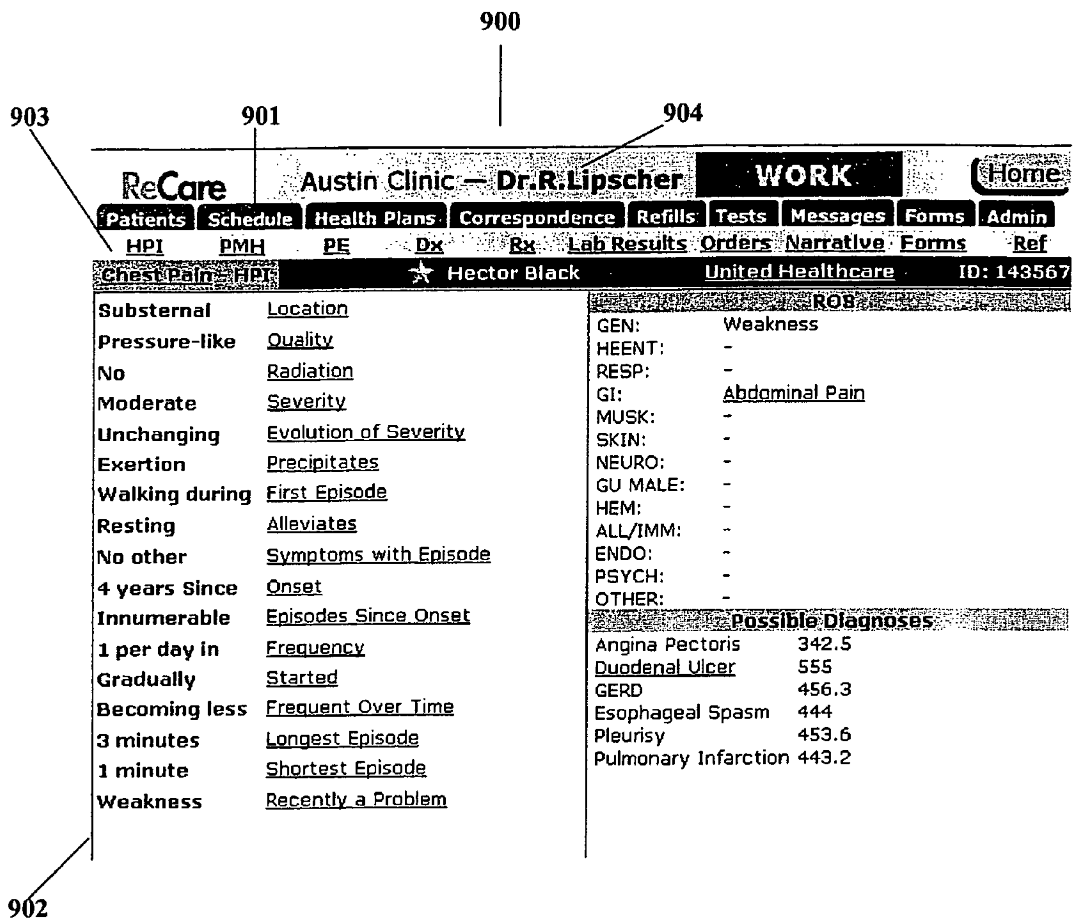

900
903
901
904
ReCare
Austin Clinic — Dr.R.Lipscher
WORK
Home
Patients
Schedule
Health Plans
Correspondence
Refills
Tests
Messages
Forms
Admin
HPI
PMH
PE
Dx
Rx
Lab Results
Orders
Narrative
Forms
Ref
Chest Pain - HPI
Hector Black
United Healthcare
ID: 143567
Substernal Location
Pressure-like Quality
No Radiation
Moderate Severity
Unchanging Evolution of Severity
Exertion Precipitates
Walking during First Episode
Resting Alleviates
No other Symptoms with Episode
4 years Since Onset
Innumerable Episodes Since Onset
1 per day in Frequency
Gradually Started
Becoming less Frequent Over Time
3 minutes Longest Episode
1 minute Shortest Episode
Weakness Recently a Problem
ROS
GEN: Weakness
HEENT: -
RESP: -
GI: Abdominal Pain
MUSK: -
SKIN: -
NEURO: -
GU MALE: -
HEM: -
ALL/IMM: -
ENDO: -
PSYCH: -
OTHER: -
Possible Diagnoses
Angina Pectoris 342.5
Duodenal Ulcer 555
GERD 456.3
Esophageal Spasm 444
Pleurisy 453.6
Pulmonary Infarction 443.2
902

FIG. 8

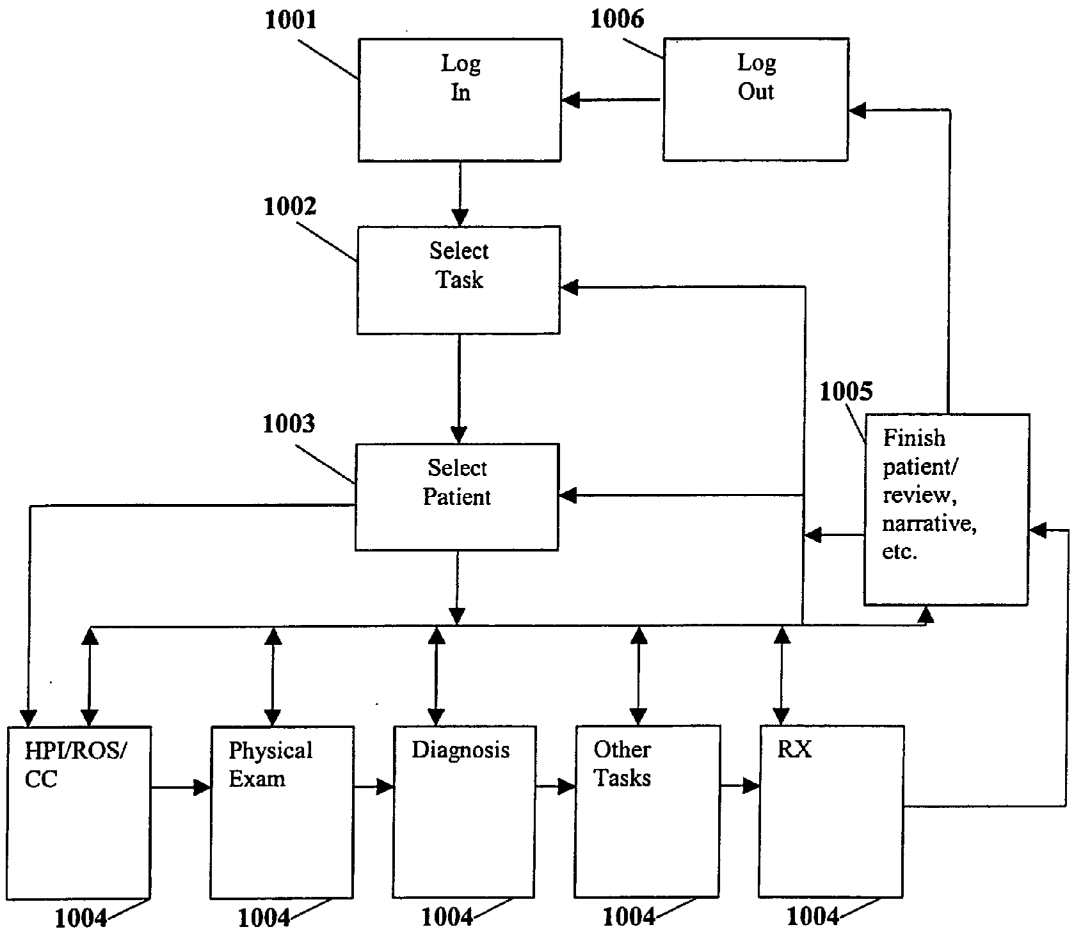

1001
Log In
1006
Log Out
1002
Select Task
1003
Select Patient
1005
Finish patient/ review, narrative, etc.
HPI/ROS/ CC
Physical Exam
Diagnosis
Other Tasks
RX
1004
1004
1004
1004
1004

FIG. 9

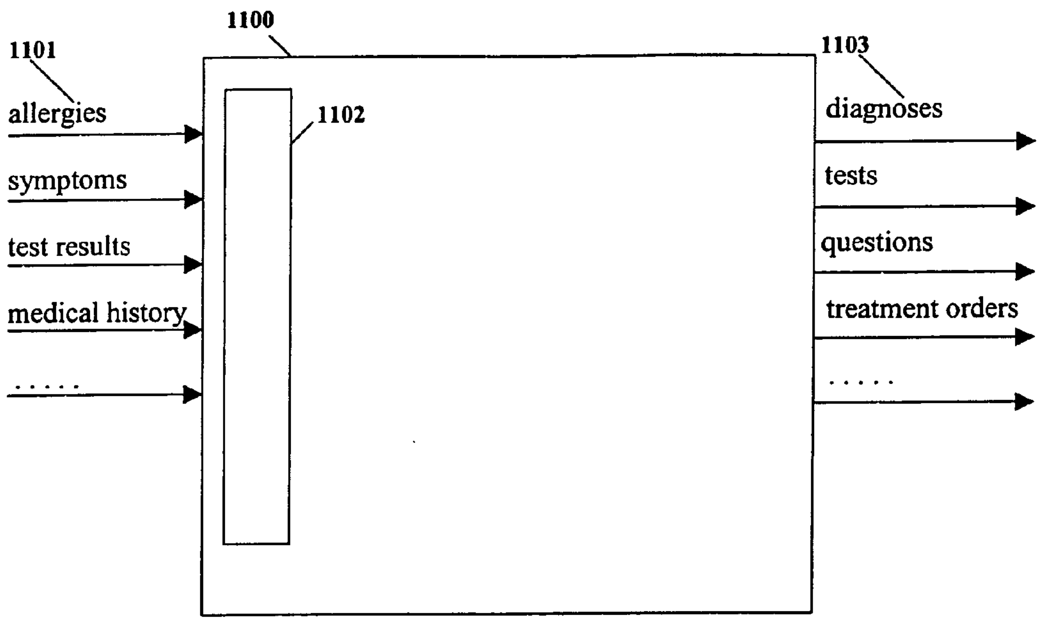
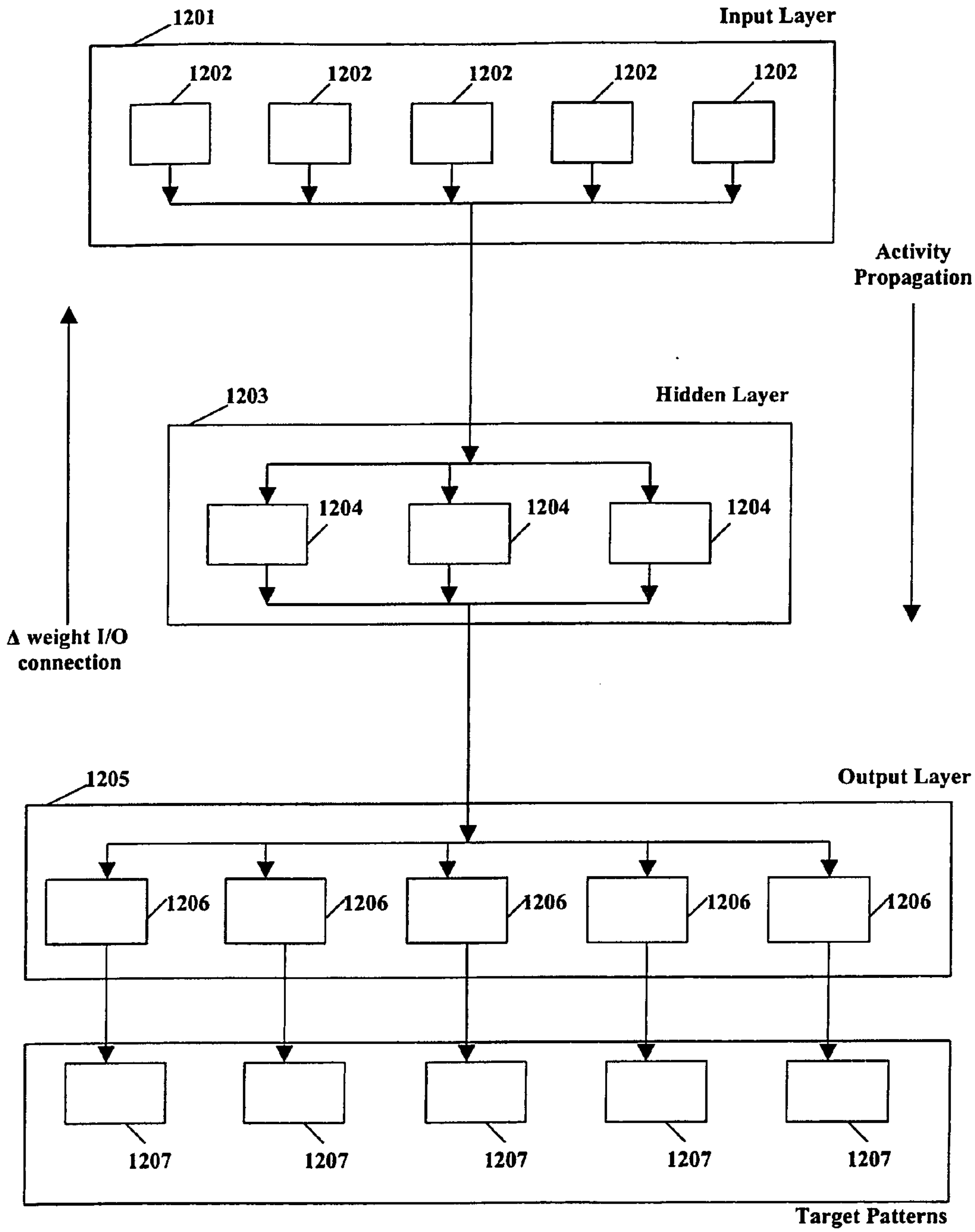

1100
1101
allergies
symptoms
test results
medical history
. . . . .
1102
1103
diagnoses
tests
questions
treatment orders
. . . . .

FIG. 10



1201
Input Layer
1202
1202
1202
1202
1202
Activity Propagation
1203
Hidden Layer
1204
1204
1204
Δ weight I/O connection
1205
Output Layer
1206
1206
1206
1206
1206
1207
1207
1207
1207
1207
Target Patterns

FIG. 11

SYSTEMS AND METHODS FOR ADAPTIVE MEDICAL DECISION SUPPORT

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] The present application claims priority from U.S. non-provisional patent application Ser. No. 09/690,354, filed Oct. 17, 2000, entitled "SYSTEMS AND METHODS FOR ADAPTIVE MEDICAL DECISION SUPPORT," naming inventors Risto Miikkulainen, Michael Dahlin, and Randolph Lipscher, which application is incorporated by reference herein in its entirety.

FIELD OF THE DISCLOSURE

[0002] The present disclosure relates generally to computer-implemented systems and methods of gathering and analyzing medical information and adaptively supporting medical decision-making.

BACKGROUND

[0003] As a result of increasing populations, the per capita number of physicians in decreasing. Thus, medical professionals have ever-increasing pressure to be more efficiently in serving their growing patient numbers, while maintaining consistent levels of quality and accuracy. Many medical professionals use electronic medical records systems (EMR systems) to aid their practices. EMR systems can bring standardization to the storage and presentation of medical information and can provide consistent access to medical information.

[0004] Though EMR systems bear some advantages, the systems do not always increase efficiency to degrees that merit the time and cost of building and implementing them. For instance, many such systems have one or a few centralized points of access-terminals or other computing devices at which data may be entered and received. Users often collect data themselves and subsequently enter the collected data into the system, nearly doubling the work. These points of access are also used to access data. While electronic access is typically faster than sorting through paper files, the data may often be accessed, printed or written, and delivered or relayed to another medical professional or patient who is not present at the access point. Again, the advantage of the systems over paper methods is only slight, when weighed against the time and cost required to build and implement the systems.

[0005] Because of the inefficiencies involved with using centralized points of access, electronic medical systems have rarely been adopted, except for storage purposes. Thus, systems that might support medical professionals, or other users, with medical decision-making have been slow to develop. In the 1970's, systems began to develop, which attempted to integrate clinical decision support with electronic medical records, by flagging errors or symptoms and by suggesting questions, tests, diagnoses or treatments. But again, users could access the systems only after locating one of a certain few designated hardware devices. The user was required to enter information, wait for system suggestions, and relay the information to others at remote locations. In medical practices, this often frustrated both the medical professional and the patient, by disrupting patient-doctor interactions and the fluid course of business within medical care facilities.

[0006] Over time, the systems have become more specialized. But, as expensive and time-consuming as these systems are to build, they are only made more cumbersome by tailoring them to meet the desires of individual users. Medical practitioners, for example, often practice in specialized fields, such as cardiology or pediatric surgery. General practitioners often serve specific patient populations. practitioners would be helped by tailoring systems to account for the peculiarities of their particular medical field and the history of cases that they have served, while also integrating their individual habits or preferences for routine diagnostic methods, terminology, certain medication types or brands, etc., into the systems. Thus, the current systems are not nearly as efficient, helpful, accurate, or easy to use, as they could be, or as users desire them to be.

[0007] As such, improved systems and methods of gathering and analyzing medical information would be desirable.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] **FIGS. 1 and 2** include illustrations of exemplary systems, in which at least one user device and at least one general use device communicate data with a host computer.

[0009] **FIG. 3** includes a table illustrating examples of patient data and medical data that may be transmitted to the host computer.

[0010] **FIG. 4** includes a table illustrating examples of information that may be transmitted to users from the host computer.

[0011] **FIG. 5** includes an illustration of an exemplary method for use by a system, such as the exemplary systems illustrated in **FIGS. 1 and 2**.

[0012] **FIGS. 6 and 7** include illustrations of exemplary systems that may implement an exemplary method, such as the exemplary method illustrated in **FIG. 5**.

[0013] **FIG. 8** includes an illustration of an electronic medical chart graphical user interface.

[0014] **FIG. 9** includes an illustration of an exemplary method that may be implemented by a system, such as the exemplary systems illustrated in **FIGS. 1, 2, 6** and **7**.

[0015] **FIG. 10** includes an illustration of an exemplary implementation of a learning-based model.

[0016] **FIG. 11** includes an illustration of an exemplary implementation of a neural networks system.

DETAILED DESCRIPTION

[0017] In a particular embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving a first input from a first device, receiving a second input from a second device, determining a suggested medical decision based at least in part on the first input and the second input, and transferring the suggested medical decision to the second device.

[0018] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving a medical input from a user device, determining a first suggested decision from a first predictive model, determining a second suggested decision from a second predictive model, and transferring the first suggested decision and the second suggested decision to the user device.

[0019] In a further exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving a user medical input and a user medical decision from a device, determining a suggested result based at least in part on the user medical input, comparing the user medical decision to the suggested result, and providing an indication based at least in part on comparing the user medical decision to the suggested result.

[0020] In an additional embodiment, a computer-implemented method for adaptively supporting decisions of at least one user includes receiving a set of user inputs, training a model based at least in part on the set of user inputs, and adjusting the model based at least in part on a set of outlier inputs.

[0021] Typically, electronic medical records (EMR) provide a user interface via terminals or other computing devices (collectively, user interface devices). The user interface may include one or more methods of displaying data, such as text arranged on a screen, icons, schematics, pictures, or audio, and this user interface can include one or more methods of input, such as keyboard text input, virtual keyboard text input, handwriting recognition text input, mouse position or selection input, stylus position or selection input, touch screen position or selection input, mouse drawing input, touch-screen drawing input, stylus drawing input, voice input, medical device input, remote computer input. An EMR may also be referred to as a graphical medical record. In a particular embodiment, an EMR may include discrete input controls, such as check boxes, three-mode controls, radio buttons, which collect discrete findings for storage in relation to a patient. Findings include, for example, associated conditions, ailments, corporal location, medical history, patient data, testing, prescriptions, and other medical data.

[0022] Referring to **FIG. 1**, an exemplary embodiment of a system includes at least one user device **100**. These devices **100** allow users to communicate medical data with a host computer **102**. In an example, the user device **100** includes a portable computing device that is capable of communicating with other computing devices via a wireless communication link **101**. The user device **100** may include a portable computing device, such as a handheld wireless computing device, a wireless tablet form factor device, or a desktop or laptop computing device. The user device **100** may also include a computing device linked or integrated with a medical instrument. Typically, the user interacts with the user device **100** using a graphical user interface (GUI). In an embodiment, the GUI includes an electronic medical chart interface that presents and organizes data, such as EMR data.

[0023] In an exemplary embodiment, a user enters data via the user device **100**, which transmits the data via the wireless communication link **101** to the host computer **102**. The data may include patient data, clinical data, or instructions to be executed by the host computer **102**. The host computer **102** may be a computing device or a set of computing devices capable of receiving, transmitting, storing, and analyzing data, and executing operations. The host computer **102** may be a portable personal computer, a desktop personal computer, a handheld computing device that is capable of communicating remotely with other computers, or it may be a web server computer.

[0024] The wireless communication link **101** may include technology that can relay signals between a wireless computing device **100** and a host computing device **102**. Such wireless links **101** may include infrared signals, radio frequency signals, pulse codes, or frequency-diode modulation. In a particular embodiment, the wireless communication link **101** may use wireless protocols, such as IEEE 802.11 a, b, or g, IEEE 802.15, or IEEE 802.16.

[0025] In an embodiment, one or more additional users may enter data via the user devices **100**, which transmit the data via the wireless communication link **101** to the host computer **102**. The data may include patient data, clinical data, or instructions to be executed by the host computer **102**. For example, a patient may enter data about his condition using a user device **100** and those data may be transmitted to the host computer **102** via the wireless communication link **101**. In another example, a medical technician or laboratory may enter data via a user device **100**, which transmits the data via the wireless communication link **101** to the host computer **102**. This data may include the results of medical tests on a patient.

[0026] The host computer **102** may also retrieve additional data from computers that are external to the host computer **102**. This data may include patient data, clinical data, or instructions to be executed by the host computer **102**. In the embodiment illustrated in **FIG. 1**, the external computers include at least one informational computer **104**.

[0027] The host computer **102** may retrieve information that it transmits to the user from its own memory. The host computer **102** may also, or alternatively, retrieve information that the host computer **102** transmits to the user from computers that are external to the host computer **102**. In the embodiment illustrated in **FIG. 1**, the host computer **102** retrieves information from at least one informational computer **104**. Where multiple informational computers **104** are used, they may geographically distributed and remotely located. The host computer **102** may communicate with each informational computer **104**, such as wired or wireless methods, and may include communication via global network, such as Internet, wide area network, or local area network. In an embodiment, each informational computer **104** is a server computer with which the host computer **102** communicates across a network.

[0028] The user device **100** may retrieve the information it provides to the user from its own memory, or from one or more external computers. In the embodiment shown in **FIG. 1**, the user device **100** retrieves information from at least one informational computer (IC) **104**, with which the user device **100** communicates. The user device **100** may communicate with each informational computer **104** via a suitable component for communication among computing devices. In the embodiment shown in **FIG. 1**, the user device **100** communicates with each informational computer **104** by transmitting signals to the host computer **102**, via the wireless communication link **101**. The signals are transmitted to the informational computers **104**. The informational computers **104** return information to the host computer **102**, which sends signals back to the user device **100**.

[0029] The host computer **102** may communicate with the informational computers **104**, via a wireless communication link **101**. Alternatively, the host computer **102** may communicate with informational computers **104**, via wired communication, such as a global network (such as the Internet), a wide area network, or a local area network. Alternatively, the host computer **102** may be integrated or attached with at least one informational computer **104**.

[0030] The system may also provide at least one port (not illustrated). The user device **100** may be "docked" at a port (i.e., connected to a wired network) to facilitate wired communication with the host computer **102** and informational computers **104**. This communication may include communication via a global network (such as Internet), a wide area network, or a local area network. Docking may be used, for example, for interacting with the host computers **102** and informational computers **104** in circumstances where patient/medical professional relationships are not disrupted or may be disrupted. Examples of circumstances where relationships are not disrupted include maintenance of the system, software installation, or where "batch" entry or review of medical data is desired. An example of circumstances where the relationship may be disrupted includes a case that is especially difficult and requires an atypically lengthy amount of study and analysis. The user device **100** may be connected at a port by a docking component connecting a computing device to a docking port. These may include plugging one end of an electrical or optical cable into a port and the other end into a port or socket on the user device **100**.

[0031] The host computer **102** receives data and responds by executing operations and transmitting information. The host computer **102** may also store the data. In an embodiment, the data is stored on the host computer **102** in the form of an electronic chart. The data may also be stored on computers that are external to the host computer **102**. In the embodiment illustrated in **FIG. 1**, the data is stored on informational computers **104** with which the host computer **102** communicates. The host computer **102** transmits information to the user device **100** via wireless communication link **101**. Examples of transmitted information may include recommended diagnostic questions or tests that serve to reduce the probability of oversights during medical examination; past medical information for the patient; alternatives for diagnoses and treatment orders; and medical information, such as journal articles and the like. The host computer **102** may provide relevant information and recommendations to the user and may execute operations and provide information automatically or in conformity with user instructions.

[0032] The host computer **102** may also retrieve information that it transmits to the user from a user device **100** or a general use device **103** used by a different user to enter medical information. In an embodiment, a patient logs in and enters medical information about his condition into one user device **100** and this information is transmitted to the user device **100** used by a medical doctor via the host computer **102**. In another embodiment, a patient logs in and enters medical information about his condition into one general use device **103** and this information is transmitted to the user device **100** used by a medical doctor via the host computer **102**. In such an embodiment, the general use device **103** used by the patient is a personal computer, which receives information from and transmits information to the host computer **102** via the Internet. For example, the host computer **102** can implement a web server interface, the general use device **103** can implement a web browser interface, and an electronic medical record interface can be implemented using JavaScript and HTTP to allow the general use device **103** to act as an electronic medical record interface to allow log-in and data entry by a patient. In an embodiment, the data is stored in the form of an electronic chart, onto one or more informational computers **104**, with which the user device **100** communicates.

[0033] Where the host computer **102** acts automatically, it does so by predicting decisions that the user, a separate user, or group of users can make during the course of treating each patient. Such decisions may pertain to elements of medical examination, such as questions, findings, lab tests, clinical tests, or imaging; diagnosis and resulting treatment orders; and information that the user may desire, such as patient history information, the opinions and recommendations of medical specialists or other medical professionals, similar cases that the user has served, and instructive information, such as journal articles and the like. Upon predicting user decisions, the host computer **102** forwards data pertaining to each decision that it has predicted. For example, upon receiving data from the user, the host computer **102** may predict a certain diagnosis and forward pertinent journal articles or suggested treatment orders to the user, to a separate user, or to a collection of users. In another embodiment, the host computer **102** may suggest diagnostic tests or questions that can eliminate potential oversights in the user's rendering of diagnoses or treatment orders.

[0034] Where the host computer **102** performs operations and forwards information according to user choice, the host computer **102** predicts the decisions that may be made by user and presents these decisions to the user by displaying the decisions on the user device **100**. The user may select from the decisions predicted by the host computer **102**, or enter alternative selections. In an embodiment, the host computer **102** displays the predicted decisions in the selected state (e.g., by showing a check mark in a check box) and the user may leave the box checked to select the decision predicted by the host computer **102** or the user may uncheck the box and select an alternative selection, such as an alternative check box. The host computer **102** provides information or executes operations according to the user's input, which may include one or more of the predicted decisions or decisions different from the predicted decisions. For example, upon receiving patient or clinical data about a patient from the user, the host computer **102** may predict a certain diagnosis or range of diagnoses and display the diagnoses to the user via the user device **100**. The user may enter a selection via the user device **100**, such as a selection from among the diagnoses displayed. The user may also enter a diagnosis or range of diagnoses that are not suggested by the host computer **102**. In another example, upon receiving patient or clinical data about a patient from the user, the host computer **102** may suggest that a particular test may be ordered and display that test with a checkbox indicating that that test has been selected. The user may leave the checkbox in the checked state to select the suggested decision, or the user may uncheck the box to override the decision. In another embodiment, the host computer **102** suggests that a certain medication be prescribed and display that medication with a checkbox and a suggested dosage selected. The user may override the selection or change the dosage or leave the selection as suggested. For another example, upon receiving patient or clinical data about a patient from the user, the host computer **102** may predict a list of likely decisions by the user, such as a list of tests to perform, medications to prescribe, or diagnoses to identify; after displaying this list, the system receives a selection of a decision from this list or from other orders displayed as options to the user. Upon receiving the user's entry, the host computer **102** may execute operations such as retrieving information, such as journal articles, updating files, or suggesting treatment orders or further diagnostic tests or questions. The host computer **102** displays resulting information to the user via the user device **100**.

[**0035**] The host computer **102** makes suggestions about a user's or a group of users' medical decisions, via a learning component that may execute behavioral models; rule-based algorithms, including rules, static lists, and decision support systems, such as MEDCIN; learning-based algorithms; neural networks; or any combination of these. In an embodiment, the host computer **102** utilizes a combination of rule-based algorithms and learning-based algorithms. In this embodiment, the host computer **102** maintains a behavioral model of the user to make suggestions of decisions that the user can make. During an initial period of use, the behavioral model is essentially empty. Thus, the host computer **102** makes suggestions based on rule-based algorithms. The behavioral model is updated when data and decisions are received from the user. As the behavioral model develops, suggestions may be made based on both rule-based algorithms and the learning-based behavioral model. The resulting information may be merged together, producing a single output, or the information of each type may be separate and made selectable by the user. In an example, the user has the option to disable the rule-based algorithms, when the user determines that the behavioral model has progressed beyond the rule-based algorithm. Additionally, the user may disable the learning component, such that the predictive capability remains, without updating.

[**0036**] In another embodiment, each operation performed by the host computer **102** includes a plurality of decision nodes. The host computer **102** may employ a neural network at each decision node, for suggesting the decision that can be made by a user at the decision node. The host computer **102** may be programmed to execute the suggested decision or the decision input by the user. The host computer **102** updates each neural network, after receiving data and actual decisions from the user.

[**0037**] Regardless of the embodiment of the learning component, the suggestion process is thus adapted to the user, such that the host computer **102** attempts to predict and suggests the decisions actually input by a user in one case, when similar data or combinations of data are received in another case. But, the predictive process may also be updated, by predictively customizing the operations to the user's habits and preferences, while taking into account the characteristics of the user's specialty and patient populations. For instance, by updating its learning module with user habits, preferences, etc., the host computer **102** can increase its ability to predict when the user is likely to consult the virtual specialist feature, what medications the user prefers to prescribe for various ailments, what tests or diagnoses, if any, are commonly or uniformly rendered among the user's patient populations, etc. Thus, in addition to better predicting diagnoses and pertinent information, the host computer **102** can tailor the details of its operations to the user's habits and preferences.

[**0038**] Regardless of the algorithms or models employed by the learning component, the host computer **102** may update the learning component each time that data or decisions are received from the user. Alternatively, updating may occur in "batch form," whereby updating occurs after a set period, such as after each case is complete, after a pre-defined number of cases are complete, after a pre-defined time period elapses, or after a pre-defined amount of data or decisions are received from the user, or a combination of these.

[**0039**] The system also provides at least one general use device **103** for interacting with the host computer **102**. The general use device **103** is a computing device that communicates with the host computer **102** and may be non-portable. For example, the general use device **103** may be a terminal computer that is dedicated to the host computer **102**. The communication link between the general use device **103** and the host computer **102** may be wireless or wired. The communication may include communication via a global network, such as the Internet, a wide area network, or a local area network. In an embodiment, the general use device **103** includes at least one desktop computer that is centrally-located in an environment, such as a hospital, employing the system and is used for interacting with the host computer **102**, in circumstances where patient/medical professional relationships are not disrupted or may be disrupted. Examples of circumstances in which relationships are not disrupted include maintenance of the system or software installation, or where "batch" entry or review of medical data is desired. Examples of circumstances in which relationships may be disrupted include cases that are especially difficult and that use an atypically lengthy amount of study and analysis.

[**0040**] In an embodiment, the system provides a user interface that displays medical data elements using one or more human readable natural languages or variations of natural language for different audiences (e.g., technical v. lay). Internally, however, the system represents medical data elements as numerical codes or distinguished nomenclature items. For example, the numerical code for hypertension might be "1000", and the display text for hypertension might be "hypertension" (English, technical), "high blood pressure" (English, lay), "Bluthochdruck" (German), "hipertension" (Spanish), or "hypertensie" (Dutch.) Such a translation may facilitate developing models of doctors who speak language A and using those models for doctors who speak language B. Such a translation may also facilitate communication by doctors who speak language A with patients who speak language B. Additionally, such translation may also facilitate input of medical data by non-medically-trained users such as patients in a first language and output of the medical data in a second language readable by a physician.

[**0041**] Regardless of the embodiment of the learning component, the prediction process is thus adapted to the user, such that the user device **100** may predict the decisions actually input by a user in one case, when similar data or combinations of data are received in another case. But, the predictive process may also be updated, by predictively customizing the operations to the user's habits and preferences, while taking into account the characters of the user's specialty and patient populations. For instance, by updating its learning module with user habits, preferences, etc., the user device **100** can increase its ability to predict when the user is likely to consult the virtual specialist feature, what medications the user prefers to prescribe for various ailments, what tests or diagnoses, if any, are commonly or uniformly rendered among the user's patient populations, etc. Thus, in addition to better predicting diagnoses and pertinent information, the user device **100** can tailor the details of its operations to the user's habits and preferences.

[**0042**] Referring to **FIG. 2**, an alternative embodiment includes at least one user device **300**. The user device **300** includes a portable computing device that is capable of communicating with other computing devices via a wireless communication link. The user device **300** may include a portable computing device, including those examples described with reference to **FIG. 1**. The user interacts with the user device **300** using a graphical user interface (GUI). In an embodiment, the GUI includes an electronic medical chart interface that presents and organizes the data. A user enters data via the user device **300**, which transmits the data via wireless communication link **301** to the receiver/transmitter **305**. The data may include patient data, clinical data, or instructions to be executed by the host computer **302**, such as particular information that the host computer **302** is to retrieve, analyze, or transmit. The receiver/transmitter **305** relays signals that correspond to information and instructions between the host computer **302** and each user device **300**. The receiver/transmitter **305** may be attached or integrated with the host computer **302**, or it may communicate with the host computer **302** by remote component, such as wireless or network technologies. The host computer **302** may include an embodiment selected from the examples described in relation to **FIG. 1**.

[**0043**] Communication with the receiver/transmitter **305**, by the host computer **302** and each user device **300**, may be achieved using technology for relaying signals between a wireless computing device and a signal receiver/transmitter **305**. Such wireless technologies may include infrared signals, radio frequency signals, pulse codes, or frequency-diode modulation. In an embodiment, radio frequency signals are used to accomplish the wireless transmission of data from the wireless devices to a radio signal receiver/transmitter. In particular, the receiver/transmitter **305** may communicate using standard protocols, such as IEEE 802.11 a, b, g, IEEE 802.15, or IEEE 802.16.

[**0044**] In an embodiment, multiple decisions are predicted or executed. For example, if a triage nurse enters into the system that a patient reports chest pain, the system may predict the following actions: (1) page doctor, (2) page nurse, (3) get chest x-ray, and (4) order an electro-kardiogram (EKG). In an embodiment, the system could communicate with a network to initiate some of these actions by (1) sending a message to the on-call doctor's pager or EMR device, (2) sending a message to the on-call nurse's pager or EMR device, (3) scheduling a chest x-ray with the radiology department, and (4) reserving an EKG machine and transmitting a message to a staff member to bring the EKG machine to the patient and connect it to the patient.

[**0045**] In an embodiment, the step of executing a decision includes electronically transmitting instructions to a medical device. For example, executing a decision may include requesting that a medical monitoring device take a reading, store a reading, change monitoring parameters, or transmit a reading. In a particular example, the host device **302** may direct a blood pressure monitor connected to a patient to obtain a blood pressure of the patient. In another example, the host system may query a heart rate monitor for a heart rate associated with the patient.

[**0046**] In an embodiment, data may be received from various sources. For example, a doctor may enter data via an EMR interface, a nurse may enter data via an EMR interface, a patient may enter data via an EMR interface, a medical device may transmit data electronically, a remote lab computer may transmit data electronically, and a remote medical data storage computer may transmit data electronically. In an embodiment, multiple clinics may receive information about a patient, and when a doctor at a first clinic is working with a patient, data entered about the patient at other clinics may be used as input to the prediction process. For example, if a patient is visiting a primary care physician and multiple specialists, data sharing capability allows the system to detect and warn a user of redundant prescriptions issued by different clinics. Such a capability can both prevent inadvertent mistakes and also "doctor shopping" where a patient attempts to get multiple prescriptions for the same controlled substance from multiple physicians.

[**0047**] In an embodiment, one or more additional users may enter data via the user devices **300**, which transmit the data via the wireless communication link **301** to the host computer **302**. This data may include patient data, clinical data, or instructions to be executed by the host computer **302**. For example, a patient may enter data about his condition using a user device **300** and those data may be transmitted to the host computer **302** via the wireless communication link **301**. For example, a medical technician or laboratory may enter data via a user device **300**, which transmit the data via the wireless communication link **301** to the host computer **302**. The data may include the results of medical tests on a patient.

[**0048**] The host computer **302** may also retrieve additional data from computers that are external to the host computer **302**. This data may include patient data, clinical data, or instructions to be executed by the host computer **302**. In the embodiment shown in **FIG. 2**, the external computers include at least one informational computer **304**.

[**0049**] As illustrated in **FIG. 2**, the system may also provide at least one port **303**. The user device **300** may be "docked" at ports **1** through n **303** (i.e., connected to a wired network) to facilitate wired communication with the host computer **302**. The communication may include communication via global network (such as Internet), wide area network, or local area network. Docking is used for interacting with the host computer **302**, in circumstances where patient/medical professional relationships are not disrupted or may be disrupted. Examples of circumstances where relationships are not disrupted include maintenance of the system, software installation, or where "batch" entry or review of medical data is desired. An example of circumstances where the relationship may be disrupted includes a case that is especially difficult and uses an atypically lengthy amount of study and analysis. The user device **300** may be connected at ports **1** through n **303**, by a method for connecting a computing device to a docking port. The method may include plugging one end of an electrical or optical cable into port n **303** and the other end into a port or socket on the user device **300**.

[**0050**] In an embodiment, the host computer **302** receives data and responds by executing operations and transmitting information. The host computer **302** may store the data received from the user. In an example, the data is stored in the form of an electronic chart onto one or more informational computers **304** with which the host computer **302** communicates. The host computer **302** transmits information to the user device **300** via a wireless communication link **301** and a receiver/transmitter **305**. Examples of the information may include recommended diagnostic questions or tests that serve to reduce the probability of oversights during physical examination; past medical information for the patient; alternatives for diagnoses and treatment orders; and medical information, such as journal articles and the like. The host computer **302** may provide relevant information and recommendations to the user and may execute operations and provide information automatically or in conformity with user instructions. In an embodiment, the host computer **302** displays the suggested decisions in the selected state (e.g., by showing a check mark in a check box) and the user may leave the box checked to select the decision predicted by the host computer **302** or the user may uncheck the box and select an alternative selection, such as an alternative check box. Where the host computer **302** acts automatically, the host computer **302** suggests decisions that the user may make during the course of treating each patient. The suggested decisions may pertain to elements of physical examination, such as questions, lab tests, clinical tests, or imaging; diagnosis and resulting treatment orders; and information that the user desires, such as patient history information, the opinions and recommendations of medical specialists or other medical professionals, similar cases that the user has served, and instructive information, such as journal articles and the like.

[**0051**] Upon suggesting user decisions, the host computer **302** forwards data pertaining to each user decision that is suggested. For example, upon receiving patient or clinical data about a patient from the user, the host computer **302** may predict a certain diagnosis or range of diagnoses and display the diagnoses to the user via the user device **300**. The user may enter a selection via the user device **300**, such as a selection from among the diagnoses displayed. The user may also enter a diagnosis or range of diagnoses that are not suggested by the host computer **302**. In another example, upon receiving patient or clinical data about a patient from the user, the host computer **302** may suggest that a particular test may be ordered and display that test with a checkbox indicating that that test has been selected. The user may leave the checkbox in the checked state to select the suggested decision, or the user may uncheck the box to override the decision. In another embodiment, the host computer **302** suggests that a certain medication be prescribed and display that medication with a checkbox and a suggested dosage selected. The user may override the selection or change the dosage or leave the selection as suggested. In another example, upon receiving patient or clinical data about a patient from the user, the host computer **302** may predict a list of likely decisions by the user, such as a list of tests to perform, medications to prescribe, or diagnoses to identify; after displaying this list, the system receives a selection of a decision from this list or from other orders displayed as options to the user. In a further example, upon receiving data from the user, the host computer **302** may predict a certain diagnosis and forward pertinent journal articles or suggested treatment orders to the user. In another embodiment, the host computer **302** may suggest diagnostic tests or questions that can eliminate potential oversights in the user's rendering of diagnoses or treatment orders.

[**0052**] Where the host computer **302** performs operations and forwards information according to user choice, the host computer **302** suggests the decisions that may be made by user and presents these decisions to the user by displaying them on the user device **300**. The user may select from the decisions suggested by the host computer **302**, or enter alternatives. The host computer **302** provides information or executes operations according to the user's input, which may include one or more of the predicted decisions or decisions other than those that were predicted. For example, upon receiving patient or clinical data about a patient from the user, the host computer **302** may predict a certain diagnosis or range of diagnoses and display these diagnoses to the user via the user device **300**. The user may enter a selection via the user device **300** from among the diagnoses displayed, or the user may enter a diagnosis or range of diagnoses that are not displayed in response to the host computer **302** suggestion. Upon receiving the user's entry, the host computer **302** may execute operations such as retrieving information, such as journal articles, updating files, or suggesting treatment orders or further diagnostic tests or questions. The host computer **302** displays resulting information to the user via the user device **300**.

[**0053**] In an exemplary embodiment, the host computer **302** makes suggestions about a user's medical decisions via a learning component that may execute behavioral models, rule-based or learning-based algorithms, and neural networks, or a combination thereof, such as in a manner described in relation to **FIG. 1**.

[**0054**] In an embodiment, the host computer **302** utilizes a combination of rule-based algorithms and learning-based algorithms. In such an embodiment, the host computer **302** maintains a behavioral model of the user to suggest decisions that the user may make. During an initial period of use, the behavioral model is essentially empty. Thus, the host computer **302** makes suggestions based on rule-based algorithms. The behavioral model is updated when data and decisions are received from the user. As the behavioral model develops, suggestions may be made based on both rule-based algorithms and the learning-based behavioral model. The resulting information may be merged together, producing a single output, or the information of each type may be presented separately and made separately selectable by the user. The user has the option to disable the rule-based algorithms, such as when the user determines that the behavioral model has progressed beyond the rule-based algorithms. Additionally, the learning component may be disabled by the user instruction such that the predictive capability remains without updating.

[**0055**] Regardless of the embodiment of the learning component, the prediction process is thus adapted to the user, such that the host computer **302** may predict the decisions actually input by a user in one case, when similar data or combinations of data are received in another case. The prediction process is thus adapted to the user, such that the host computer **302** may predict the decisions actually input by a user in one case, when similar data or combinations of data are received in another case. But, the predictive process may also be updated by customizing the operations to the user's habits and preferences, while taking into account the characteristics of the user's specialty and patient populations. For instance, by updating its learning module with habits, preferences, etc., of the user, the host computer **302** can increase its ability predict when the user is likely to consult a virtual specialist feature, what medications the user prefers to prescribe for various ailments, what tests or diagnoses, if any, are commonly or uniformly rendered among the user's patient populations, etc. Thus, in addition to better predicting diagnoses and pertinent information, the host computer **302** can tailor the details of its operations to the user's habits and preferences.

[0056] Regardless of the algorithms or models employed by the learning component, the host computer **302** may update the learning component each time data or decisions are received from the user. Alternatively, updating may occur in "batch form," whereby updating occurs after a set period, such as after each case is complete, after a pre-defined number of cases are complete, after a pre-defined time period elapses, or after a pre-defined amount of data or decisions are received from the user, or a combination thereof. The host computer **302** may also update the learning component each time that the user device **300** is docked at a port n **303**.

[0057] The host computer **302** may retrieve the information transmitted to the user from one or more informational computer (IC) **304** with which the host computer **302** communicates. The host computer **302** may communicate with each informational computer **304** via a method of communicating among computing devices. This may include wireless and wired methods, and may include communication via a global network (such as Internet), a wide area network, or a local area network. In an embodiment, each informational computer **304** is a server computer with which the host computer **302** communicates across a network.

[0058] **FIG. 3** includes a table **400** that displays exemplary data that may be transmitted by a user to the host computer, via a user device or a general use device, as described in relation to **FIGS. 1 and 2**. The column at **401** shows examples of patient data that may be transmitted to the host computer. The column at **402** shows examples of clinical data that may be transmitted to the host computer. Examples of patient data **401** that may be transmitted to the host computer include a patient's name and personal contact information, name and contact information of one to contact in emergency, as well as social security number and birthdate. Patient data may also include, but is not limited to, information bearing upon medical diagnosis and treatment, such as ethnicity, medical history, Do-Not-Resuscitate (DNR) orders, allergies to drugs and other allergens, current and prior medications, and health habits, such as smoking, toxic exposure, and use of drugs or alcohol. Examples of patient data may also include payment-related information, such as insurance information and employment data. The list in **FIG. 3** is intended to be illustrative and not all inclusive. It may be appreciated that many other types of patient data may be transmitted also.

[0059] Examples of clinical data **402** that may be transmitted to the host computer include vital information, such as height, weight, body temperature, pulse rate, blood pressure, pulse oxygenation, blood type, and blood pH. Examples of medical data may also include data that is directly pertinent to diagnosing a medical problem, such as the patient's complaints and symptoms, physical examination findings and laboratory results, and the patient's answers to diagnostic questions. Example medical data also may include the medical professional's diagnosis and treatment orders. When medication is dispensed for treatment, the medical data may include prescription instructions and information and information and instructions for the dispensing pharmacy. In addition, examples of medical data may include the date of visit by the patient, follow-up recommendations, and the name of the medical professional attending the patient on the date of visit. The list in **FIG. 3** is intended to be illustrative and not all inclusive. It may be appreciated that many other types of clinical data also may be transmitted.

[0060] **FIG. 4** includes a table **500** illustrating examples of information that may be output to a user by the host computer, as described in relation to **FIGS. 1 and 2**, in order to provide medical decision support to the user. Examples of information pertaining to patient assessment that may be output by the host computer to the user include but are not limited to recommendations for diagnostic questions, physical examinations, and medical tests, such as blood tests or imaging (X-ray, MRI, CT, etc.); medical history data concerning the patient; the name(s) and comments of any referring medical personnel(s); alerts to common oversights in patient assessment, which may be checked at medical personnel discretion; and medical information, such as journal articles and the like.

[0061] In addition, examples of information pertaining to diagnoses that may be output by the host computer to the user include, but are not limited to, names, or other identifying references, for potential diagnoses, along with a brief description of each diagnosis that is presented; recommendations for additional data (e.g., pertinent negatives) that would exclude one or more potential diagnoses; and medical information, such as journal articles and the like.

[0062] Further, examples of information pertaining to treatment orders that may be output by the host computer to the user include, but are not limited to, recommendations for treatment orders or alternative treatment orders, including presenting to the user alternative medication types and brands; alternative recommendations for surgical or non-surgical procedures; alternative recommendations for behavior modifications (e.g., bed rest) or diet modifications (e.g., fluids); and presenting the user with medical information, such as journal articles and the like.

[0063] An exemplary embodiment may also include a "virtual specialist" feature. This feature is useful for supporting the user with decisions and information pertaining to injuries or ailments that are beyond the scope of the user's judgment of assessment, diagnosis, or treatment. The feature may be based upon the experience, input, or predictive model of a separate user or a group of users. Such a feature may be accessed by user selection, or the host computer can automatically select and query a virtual consultant model based on data received from the user. For example, the host computer may use rule-based or learning-based algorithms to determine when to access the virtual specialist feature and which virtual consultant to use. To supply the virtual specialist information, the host computer draws upon information retrieved and analyzed from memory or from at least one informational computer, such as those described in relation to **FIG. 1** and **FIG. 2**.

[**0064**] When executing the virtual specialist feature, the host computer supplies the user with decisions and information that pertain to the specific ailment or injury and information regarding the probable actions or recommendations of a medical professional or group of medical professionals that specialize in a medical discipline that addresses the ailment or injury. For instance, a general medical practitioner who encounters a child suffering from poor blood circulation may not have the ability to immediately consult a pediatric surgeon or cardiologist. In an example, the system may provide a virtual specialist to meet me practitioner's query, by dispensing information about what such a specialist may most likely do or recommend, allowing treatment to continue until a consultation with a specialist can be performed. The virtual specialist may also provide the user with information that allows "meantime care," which suggests actions that may maintain the patient in sustainable condition, until a specialist arrives for in-person consultation.

[**0065**] In an embodiment, the host computer receives input from one or more collections of different medical personnel, and develops a behavioral model for each collection. A user may view predictions from collections of medical personnel, where each collection may include just one medical personnel, which may be the user or a medical personnel that is not the user, or a group of medical personnel that includes or does not include the user. Using the virtual specialist feature, the user can direct the host computer to provide information corresponding to the likely actions of "practitioner X or group Y," given the data that has been input about a patient to the host computer. For example, practitioner X may be a specialist or even a hypothetical practitioner that is programmed to reflect standard protocol among practitioners of a certain type. Group Y may be a collection of specialists, such as cardiologists, a collection of elite medical personnel, such as the group of medical personnel at Johns Hopkins, or even a hypothetical group of medical professionals in general, that reflect standard protocol among medical personnel of a certain type. As such, the virtual specialist feature may make suggestions from various perspectives. For example, upon the user accessing the virtual specialist feature in regard to a specific patient, the host computer may, for example, output a likely treatment or action to be rendered by medical personnel X, by group Y specialists, and the "standard choices" by the medical community. Such output may provide the user with several choices in an efficient manner.

[**0066**] In another embodiment of the virtual specialist feature, a general medical practitioner who is interested in improving the effectiveness of his documentation of medical encounters and of his coding or billing practices may not have billing or coding expertise. The system may provide a "virtual" specialist to meet the practitioner's interests, by predicting what an expert coding specialist would document at each phase of the encounter, by predicting questions an expert coder would ask to enhance the current documentation to increase reimbursement levels, or predicting the code an expert coder would select with regard to a particular patient encounter.

[**0067**] In an embodiment, the system may be used to improve the coding accuracy of users. For example, in an embodiment, the system stores coding decisions by users of the system. In an example, the system may learn a particular user's coding practices based on the users coding decisions. In another example, the system displays comparisons of a user's coding decision to the coding decisions of a target, such as another user, a group of users (e.g., the department or clinic as a whole, another clinic, or an exemplary coding decision model). In an embodiment, the comparison compares the coding decisions made by the user for the user's population of patients to the coding decisions made by the target for the target's population of patients. In another embodiment, this comparison adjusts for the different patient populations and findings by generating a predictive coding model for the user or for the target and (1) comparing the user's actual coding to the coding decisions that the target's predictive model generates for the same set of patients and findings or (2) comparing the decisions that the user's predictive model generates for the target's patients and findings to the targets actual decisions or (3) compares the decisions of the user's model and the target's model for a common set of input patients and findings.

[**0068**] In an embodiment, the system notifies a user that he may be over-coding when past user decisions reflect higher codes than the target decisions. Over-coding can be risky for a doctor because it may invite regulatory audits. Such a notification may be triggered when the user's mean or median coding is significantly above the targets. In another example, the notification may be triggered when at least one coding decision results in a code higher than at least one target coding decision.

[**0069**] In an embodiment, the system notifies a user that he may be under-coding when user decisions reflect lower codes than the target decisions. Such a notification is typically triggered when the user's mean or median coding is significantly below the targets. In another example, the notification may be triggered when at least one coding decision results in a code lower than at least one target coding decision.

[**0070**] In another embodiment, the stored past coding decisions or models may be viewed by a user to evaluate decisions by multiple medical staff. For example, a manager of a practice may compare the coding decisions of different physicians to determine when they are commonly over- or under-coding compared to peers. Alternatively, a manager of a practice may examine the aggregate coding decisions of the practice and compare them to a target model.

[**0071**] In a further embodiment, the system may be used to improve the diagnostic, prescribing, or disease management decisions by users by analyzing past decisions. For example, the system stores medical decisions by users of the system. In an example, the system displays comparisons of a user's medical decision to the medical decisions of a target, such as another user or a group of users (e.g., the department or clinic as a whole, another clinic, or an exemplary coding decision model). In an embodiment, the comparison compares the medical decisions made by the user for the user's population of patients to the medical decisions made by the target for the target's population of patients. In a further embodiment, the comparison adjusts for the different patient populations and findings by generating a predictive medical model for the user or for the target and (1) comparing the user's actual medical decisions to the medical decisions that the target's predictive model generates for the same set of patients and findings, (2) comparing the decisions that the user's predictive model generates for the target's patients and findings to the targets actual decisions, or (3) comparing the decisions of the user's model and the target's model for a common set of input patients and findings.

[0072] For example, a medical decision includes a decision to refer a patient with a chronic illness to a disease management program that can coordinate and monitor patient care. Such disease management programs have the potential to save significant amounts of health-care spending and improve treatment effectiveness for conditions like diabetes. The system stores decisions to refer patients to disease management programs and compares such decisions by one user to the decisions by other users or a model and notifies a user when he fails to refer one or more patients to a program. Such a notification may be immediate, such as when a chart is signed, or may be delayed (e.g., via an email to the user at the end of the day). In an example, such a notification may be triggered by a single decisions or by multiple decisions (e.g., notify a user when he fails to assign a patient to a disease management program 50% or less of the predicted times). Similarly, the system can track whether a user is prescribing a medication or class of medications when predicted, and generate a notification when prescribed when not predicted. In an embodiment, the notification goes to the user whose actions are being predicted. In another embodiment, the notification goes to a second user, such as a manager, trainer, or pharmaceutical company representative.

[0073] Now referring to **FIG. 5**, the disclosure is also directed to a method for providing adaptive medical decision support. As illustrated at **601**, a user transmits data and instructions to the host computer. The data transmitted by the user includes patient and clinical data, and may include data that are exemplified in **FIG. 3**. The user may use the user device to communicate with the host computer via a wireless communication link. The user may also use a general use device to communicate with the host computer, via global, wide area, or local area network technology. The user may communicate with the host computer via a graphical user interface, such as an electronic medical chart interface.

[0074] As illustrated at **602**, the host computer stores and analyzes the data and executes the instructions it receives. The host computer may store the data temporarily or permanently using its own memory components, or may communicate the data to one or more informational computers for storage. As illustrated at **603**, the host computer determines whether additional information is desired or recommended and may request the additional information from the user, as illustrated at **604**. When such requests are made, the user may enter data and instructions, resulting in at least one additional iteration of **601**-**604**.

[0075] As illustrated at **605**, the host computer predicts or suggests the user's decisions from the data received and outputs these predicted decisions to the user. The host computer may also output information to the user that the host computer suggests obtaining if the user had actually made each of the decisions. For example, if the data received from the user pertains to the patient's symptoms or a medical problem, the host computer may suggest and output potential diagnoses and may also suggest further diagnostic actions, give warnings pertaining to particular diagnoses that merit further investigation of patient symptoms, provide journal articles and the like that discuss each potential diagnosis, and suggest treatment orders or courses of action. The host computer may retrieve information from its own memory components, for example, from a database, or from at least one informational computer with which the host computer communicates. Alternatively, the host computer may output the suggested decisions and await the user's instruction to retrieve pertinent information.

[0076] The host computer makes suggestions about a user's medical decisions as illustrated at **605**, via a learning component that may execute behavioral models, rule-based algorithms, learning-based algorithms, neural networks, or a combination thereof. Where a combination of rule-based algorithms and learning-based algorithms are used, the resulting information may be merged together, producing a single output, or the information of each type of algorithms may be separately displayed and made separately selectable by the user.

[0077] The output from the host computer as illustrated at **605** may include decisions and information output from a virtual specialist feature. Such decisions and information may pertain to injuries or ailments that are beyond the scope of the user's judgment of assessment, diagnosis, or treatment, and may reflect the experience, decisions, or input of a separate user or a group of users. The virtual specialist feature may be accessed by user selection, or the host computer can automatically select and query a virtual consultant model based on data received from the user. The host computer may use rule-based or learning-based algorithms to determine when to access the virtual specialist feature and which virtual consultant to use. To supply the virtual specialist information, the host computer draws upon information retrieved and analyzed from memory or from at least one informational computer.

[0078] When executing the virtual specialist feature, the host computer supplies the user with decisions and information that pertain to the specific ailment or injury and information regarding the probable actions or recommendations of a medical professional, or group of medical professionals, that specializes in a medical discipline that addresses the ailment or injury. For example, a general medical practitioner who encounters a child suffering from poor blood circulation may not have the ability to immediately consult a pediatric surgeon or cardiologist. The present system may provide a "virtual" specialist to meet the practitioner's queries by dispensing information suggesting what such a specialist may likely do or recommend, allowing time until an actual consultation can be made. The virtual specialist may also provide the user with information that allows "meantime care," which suggests actions that may maintain the patient, until a specialist arrives for in-person consultation.

[0079] As illustrated at **606**, the user receives output from the host computer, which includes the decisions predicted by the host computer, whether or not accompanied by additional pertinent information. The user may transmit more data to the host computer, in response to the output information that the user has received, resulting in an additional iteration of **601**-**606**.

[**0080**] As illustrated at **607**, the user transmits decisions to the host computer. The decisions transmitted by the user may be selected from among those decisions output to the user, or the user may input decisions that the host computer did not predict. The decisions input by the user may pertain, for example, to patient assessment, such as medical tests or physical examinations to be employed by the user. In an example, the decisions may pertain to diagnosis, such as the user's adjudged identification of a disease or injury. In another example, the decisions may pertain to treatment orders that are to be given by the user, including for example, specific procedures, types and brands of medication, or modifications in a patient's behavior or diet. In a further example, the decisions may pertain to multiple aspects of patient care. As illustrated at **608**, the host computer stores and analyzes the decisions transmitted by the user. The host computer may store the decisions temporarily or permanently using its own memory components, or on one or more informational computers with which the host computer communicates.

[**0081**] As illustrated at **609**, it is determined whether the user's decisions are final. When not, as illustrated at **610**, the host computer may output to the user additional information, such as suggestions, alternatives, warnings, and/or highlights pertaining to the decision(s) received from the user, and new suggested decisions and pertinent information as described previously. The user may receive the output, resulting in an additional iteration of **606**. The user may transmit decisions to the host computer, in response to the output suggestions, alternatives, warnings, or highlights, resulting in an additional iteration of **607**-**609**. Alternatively, the user may update or reenter data, prior to entering decisions, resulting in an additional iteration of **601**-**609**.

[**0082**] As illustrated at **611**, once the user's decisions have been made final, the host computer processes the data and decisions pertaining to a patient's case and may enhance the predictive operations by updating the host computer learning component. Where the host computer uses rule-based algorithms, the host computer may customize operations, by updating the rules. Where the host computer uses learning-based algorithms, such as a Bayesian network, inductive logic, or linear regression, in order to maintain a model a user's behavior and preferences, the host computer may update operations by updating the model. Where the host computer employs neural networks at various decision nodes, as described with reference to **FIG. 1**, the host computer updates each neural network, after receiving data and actual decisions from the user.

[**0083**] At **611**, the user may be part of one or more groups that are being modeled. In such a case, the host computer processing the data and decisions pertaining to a patient's case, and updating its operations and predictive models, take place once the user's decisions have been made final.

[**0084**] The prediction process is thus adapted to the user, such that the host computer may predict the decisions actually input by a user in one case, when similar data or combinations of data are received in another case. In another example, the predictive process may also be updated, by predicatively customizing the operations to user habits and preferences, while taking into account the characteristics of the user's specialty and patient populations. For example, by updating the learning module with user habits and preferences, the host computer can increase its ability to predict when the user is likely to consult the virtual specialist feature, what medications the user prefers to prescribe for various ailments, or what tests or diagnoses, if any, are commonly or uniformly rendered among the user's patient populations. Thus, in addition to better predicting diagnoses and pertinent information, the host computer can tailor the details of its operations to the user's habits and preferences.

[**0085**] Regardless of the algorithms or models employed by the learning component, the host computer may update the learning component each time that data or decisions are received from the user. Alternatively, updating may occur in "batch form," whereby updating occurs after a set period, such as after each case is complete, after a pre-defined number of cases are complete, after a pre-defined time period elapses, or after a pre-defined amount of data or decisions are received from the user, or a combination thereof.

[**0086**] **FIG. 6** illustrates an embodiment for using the present system and method for adaptive decision support, when the system and method are implemented in a multi-user medical environment. In this embodiment, medical professionals are placed into groups that may include one or more members. The groups may be categorized by type of professional, such as nurses, surgeons, medical personnel, medical personnel assistants (P.A.s), and medical students, among others. Groups may also be categorized by specialty or department, such as in a hospital. In such a case, medical professionals (nurses, doctors, P.A.s, etc.) who work in one specialty or department would potentially belong to the same corresponding group. Groups may alternatively include doctors who practice in one specialty, such as "cardiologists," with nurses, etc., falling into a nurse group or even a cardiology nurse group, for example. Groups may also include further specialized doctors, such as "Johns Hopkins cardiologists," or "Sarnoff fellows." Groups may alternatively include different external authorities with their own predictive models. For example, different payers may recommend or predict different medications for the same problem. Each such payer produces a model based on their own predictions, and the system uses different models for different patients depending on which payer is associated with a patient.

[**0087**] In an embodiment, the host computer receives and stores each predictive model, and it uses different models for different patients. In another embodiment, different groups may choose not to transmit their models to host computers. Instead, a host computer selects a remote prediction computer that stores a model, transmits medical findings to the remote prediction computer, the remote prediction computer generates at least one suggestion based on the medical findings and the predictive model, and the prediction computer transmits the at least one suggestion to the host computer.

[**0088**] For example, a Group I **701** may include individual internists. Each internist communicates with the host computer **704**, whether by a user device or a general use device, as are described with reference to **FIGS. 1 and 2**. In a particular example, the host computer **704** implements the exemplary method described in relation to **FIG. 5**. Data, decisions, and information that are stored on the host computer **704**, or on the informational computers **706** with which the host computer **704** communicates, are separated into a grouping that corresponds to the Group I **701**. The host computer **704** customizes operations and predictions to suit each specific internist, in accordance with the above-described method, and may create a model of the behavior, preferences, patient populations, or medical specialties of the Group I **701**. Alternatively, the Group I **701** may devise its own model and communicate the model to the host computer **704** as a Model A. Group N **702** and Group S **703** may interact with the host computer **704** in the same fashions as described for the Group I **701**.

[**0089**] One risk of adaptively trained prediction is that a system may be commonly exposed to common conditions and become unable to predict rare decisions for rare conditions. In an embodiment, the system incorporates models that include rare conditions and decisions in their prediction algorithms. For example, Model M generated by Group M **705** may include a set of findings relating to rare but dangerous conditions and the predicted decision for each such set of findings. This model may act as a training set of data to seed the customized prediction algorithms used by users with these rare cases to ensure that such rare cases can be recognized.

[**0090**] In another embodiment, the system learns to predict the set of inputs associated with a decision, such as a diagnosis or treatment. When a decision is made but the current input data falls outside of the predicted range or input data, the system predicts another decision. For example, the system can learn the set of findings typically associated with a given diagnosis. When that diagnosis is made, but the entered findings are inconsistent with that finding, the system can predict that either the findings is to be updated or the diagnosis is to be changed. In an embodiment, the system displays a warning to the user indicating that the findings are unusual for the diagnosis. In one such embodiment, the system detects "outlier" inputs that may indicate an unusual situation that warrants extra diagnostic or treatment care. For example, typically the finding of "diarrhea" predicts a diagnosis of one ore more relatively minor gastrointestinal problems. Similarly, the diagnosis of several relatively minor gastrointestinal problems predicts a finding of diarrhea. However, when the findings include both diarrhea and recent foreign travel, the unusual recent foreign travel finding is not predicted by the model for minor gastrointestinal illnesses, and the system would detect that an outlier finding exists and display a list of "outliner", "unusual", or "unexplained" finding as a warning to the user. Of course, over time, a doctor that sees a large number of patients with diarrhea and foreign travel may produce enough input/decision cases for the learning algorithm to predict decisions in such cases. Such an "outlier" mechanism can provide a component to flag cases where the model may not sufficiently account for inputs so the user should exercise special care.

[**0091**] In an embodiment, a learning algorithm or model may be periodically trained, adjusted or updated using a set of outlier inputs. For example, a user may provide inputs, such as a sequence of findings and diagnoses associated with patient visits occurring over time. These inputs may be used to train and adjust a model to accommodate a particular user's practice. However, over time, the model may tend to lose the ability to predict unusual diagnoses. To compensate, a set of outlier inputs may periodically be used to adjust the model to reintroduce unusual diagnoses not usually encountered by the user.

[**0092**] In an embodiment, updating individual and group models may be slightly altered to provide for the status of individual users. In this embodiment, only certain users' input may be used to update individual or group models that are used to implement the predictive capabilities. As a corollary, some users' models may be updated based not on their input, but upon the input of other users. For instance, the Group I **701** in **FIG. 6** may include both resident doctors at a hospital, in addition to interns who have only recently begun practicing. Thus, the system operators may elect for only the resident doctors' input and decisions to be used to update the model; and, the system may select the input and decisions of the resident doctors to be used in updating the internists' individual predictive models also.

[**0093**] In a particular example, the Group S **703** includes medical students. The system operators may select certain doctors' input and decisions to be used to update both the models and the individual predictive models for each student, even though the doctors may be placed in an entirely different group. The same may apply for the Group N **702**, for example, if the group consisted of nurses. Alternatively, system operators may allow for individual users to update their own predictive models, but particular users' input and decisions to update group models, thereby allowing for other users to evaluate their progress in learning the practice of medicine or a certain field of medicine.

[**0094**] In a further example, the Group M **705** may represent groups that transmit external or standardized models to the host computer **704**, which are not developed by the host computer **704** from processing the actions of individuals within the environment. For example, models for certain types of care that are not extensively served by a certain hospital, such as trauma, can be communicated to the host computer **704** from sources external to the hospital. Such models may be the result of standard medical practices, protocols established by those who manage the environment, such as a hospital protocol, protocols developed from evidence-based medicine, protocols developed by a payor, protocols provided by a pharmacy benefits management company, protocols developed by a pharmaceutical company, or protocols developed by business managers, including billing and coding specialists. Alternatively, protocols may be developed by elite groups of medical personnel, such as medical schools or teaching hospitals. In such cases, only the Model M is communicated to the host computer by the Group M **705**. The Group M **705** may include the creators of the model. System operators may elect for the external models to include the individual or group models for certain users, in accordance with the embodiments described above.

[**0095**] As a result of the embodiment illustrated in **FIG. 6**, the host computer **704** may provide the "virtual specialist" feature, as described in relation to **FIGS. 5 and 6**, by allowing users from different groups to access the developing models and data of other groups of users, models of individual users, and models placed on the host computer

704 by groups such as the Group M 705. Such access can result in the capacity for users to receive virtual second opinions, for example, by accessing the models of other groups, or of individual users, such as managing medical personnel.

[0096] FIG. 7 illustrates another embodiment for using embodiments of the system and method for adaptive decision support. In such embodiments, medical professionals are placed into groups. The users of each group communicate directly with each iteration of the adaptive system. For example, each of the users in the Group I 801 communicates with the host computer HCi, whether by a user device or a general use device. HCi, for example, may implement the method described in relation to FIG. 5. Data, decisions, and information for each user in the Group I 801 and corresponding models are stored on HCi or on the informational computers with which HCi communicates. HCi customizes its operations to suit each specific user in the Group I 801 and may create a model of the behavior, preferences, patient populations, or medical specialties of the Group I. A Group N 802 and a Group S 803 interact with the host computers HCn and HCs, respectively, each of which also may implement the method described in relation to FIG. 5, in the same fashion as the Group I interacts with HCi. In an embodiment, updating individual and group models may be slightly altered to provide for the status of individual users. In this embodiment, particular users' input may be used to update individual or group models that are used to implement the predictive capabilities. As a corollary, some users' models may be updated based not on their input, but upon the input of other users. For instance, the Group I 801 in FIG. 7 may include both resident doctors at a hospital, in addition to interns who have only recently begun practicing. Thus, the system operators may elect for only the resident doctors' input and decisions to be used to update the Modeli; and, also may select only the input and decisions of the resident doctors to be used in updating the internists' individual predictive models.

[0097] In an exemplary embodiment, the Group S 803 includes medical students. The system operators may select certain doctors' input and decisions to be used to update both the Models and the individual predictive models for each student, even though the doctors may be placed in an entirely different group. The same may apply for the Group N 802, for example, if the group consisted of nurses. Alternatively, system operators may allow for individual users to update their own predictive models, but for particular users' input and decisions to update group models, thereby allowing for other users to evaluate their progress in learning the practice of medicine or a certain field of medicine.

[0098] The Group M 804 may represent groups that transmit external or standardized models to the host computer, such as those described in relation to FIG. 6. In such cases, only the Model M is communicated to the host computer HCm by the Group M 804. The Group M may include the creators of the model. The separate host computers HCi, HCn, HCs, and HCm, communicate with each other directly or via a hub 805. The hub 805 may include a switching device or a computing device, such as a server computer. Communication among the host computers may take place by a method of computing devices to communicate remotely with each other. Examples include global, wide area, and local area networks. System operators may elect for the external models to include the individual or group models for certain users.

[0099] As a result of the embodiment illustrated in FIG. 7, each host computer may provide the "virtual specialist" feature by allowing users from different groups to access the continually developing models and data of other groups of users, models of individual users, and models placed on the system by groups such as the Group M 804. Such access may result in the capacity for users to receive virtual second opinions, for example, by accessing the models of other groups, or by individual users, such as managing medical personnel.

[0100] FIG. 8 illustrates an example of an electronic medical chart graphical user interface 900 that may be used in conjunction with an embodiment of the systems and methods, such as the exemplary systems described in relation to FIGS. 1-3. In this example embodiment of the GUI, various categories of information are selectable from tabs 901 labeled with the informational categories. Example categories may include Patients, Schedule, Health Plans, and the like. When a tab 901 is selected, a user may enter or choose information within an informational region 902. When information is chosen, such as a particular patient listed under the Patients tab, subcategories of information 903 are selectable by the user. The subcategories 903 (exemplified first by HPI—History of Present Illness) provide certain types of information within the informational region that are specific to, for example, the chosen patient. The information illustrated may include data and data fields to provide the user with information about the chosen information, including information exemplified in FIG. 3, but also including user-directed information, such as information about individual correspondence, schedules, messages, forms, other administrative tasks, and narratives. The GUI may also provide a login/logout feature and may include the user's name, as exemplified at 904.

[0101] FIG. 9 includes a flow diagram. As illustrated at 1001, the user logs into the system. The user may login via a portable computing device, or a general use device. In an embodiment, the user logs in, using a portable computing device that is provided with an electronic medical chart GUI. As illustrated at 1002, the user may next select the task to be performed, such as entering new data, updating data, or reviewing data. As illustrated at 1003, the user selects the patient for whom the task may be performed, which may include selecting an existing patient or opting to begin a new patient record. The user may enter, update, and review, data for a plurality of tasks 1004, such as preliminary patient information, physical examination and assessment, diagnosis, and treatment orders. During each task 1004, the method described in relation to FIG. 5 is executed. The system may allow for each task 1004 to be performed and ended directly after patient selection, without proceeding to the other tasks. The system also allows for the tasks 1004 to be performed consecutively, for example, with new patients. Once a task 1004 is completed, the user may select a new patient or a new task 1004, or the user may proceed to a finishing step 1005. The finishing step 1005 allows the user to review the results of the session and to complete administrative tasks, such as submitting narratives, changing scheduling, drafting correspondence, and the like. After the finishing **1005**, the user may proceed to another patient or task, or log out of the system at **1006**.

[0102] **FIG. 10** describes an exemplary implementation of a learning-based model for a user at a decision point implemented via neural networks. **FIG. 10** displays a learning model **1100** that receives examples of input data **1101**, which may include findings about a current patient, such as allergies, symptoms, test results, and medical history. In general, such input data are data that the medical professional considers in making a medical decision in regard to the patient. **FIG. 10** displays example outputs **1103**, which include the potential medical decisions that the medical professional may make, such as diagnoses, diagnostic tests, questions, or treatment orders. Each input variable **1101** is represented as one unit at the input layer **1102**, and is assigned an activation value. The activation value may include, for example, a numerical scale, such as a 0/1 decision, with missing values represented by e.g. 0.5. In the output **1103**, the activation of each unit represents the a posteriori probability that the choice is correct, given the training data. Thus, the system indicates what the choices are and how confident the system is in each of the choices. The network is trained with back-propagation based on the actual cases of inputs and decisions collected by the system. Standard methods of cross-validation can be used to decide when to stop training. Different training sets are constructed to model different physicians or groups of physicians. Periodically, as new data come in, the networks may be further trained with the more comprehensive data set to improve accuracy and coverage of different cases.

[0103] A neural network based learning system may be implemented using standard techniques, such as that illustrated in **FIG. 11**. This exemplary neural networks system includes an input layer **1201**, having input units **1202**; a hidden layer **1203**, having hidden units **1204**; and an output layer **1205**, having output units **1206**; and target patterns **1207**. The input layer **1201** is connected to the hidden layer **1203** by input connections that connect the input units **1202** to each of the hidden units **1204**. Similarly, the hidden layer **1203** is connected to the output layer **1205** by output connections that connect each of the hidden units **1204** to each of the output units **1206**.

[0104] The values of input variables are used to activate the input units **1202**. Each hidden unit **1204** computes a weighted sum of the input unit activations. The sums are weighted by the connection weights, which increase as one moves from the output connections to the input connections. The hidden unit **1204** outputs an activation that is a nonlinear, continuous function (such as a sigmoid or a Gaussian) of the sum. Analogously, each output layer unit **1206** computes the weighted sum of the hidden layer activations, and generates a nonlinear function of the sum as its output. The output activations are interpreted as values of output variables.

[0105] The network is trained by providing target patterns **1207**, which are correct values for the output units, with regard to each input variable. The weights of the network are changed using, for example, a back-propagation training procedure. An error signal for each output unit **1206** is formed as a difference between the output unit **1206** and the target patterns **1207**.

[0106] A gradient of the error signal with regard to the network weight values is computed, and weights are changed a step along the gradient. After the input variables and target patterns are shown several times and weights changed this way, the weights converge to values such that the network generates the correct output values for each input variable. The network may also compute the correct outputs for new examples by nonlinearly interpolating between the examples in the training set of input variables.

[0107] In an exemplary embodiment, the disclosure is directed to a computer-implemented method for adoptively supporting medical decisions of one or more users. The method includes receiving data and predicting one or more medical decisions based on the data.

[0108] Data may be received via a wireless communication component, such as infrared signals, radio signals, and pulse codes. The data may be received from the immediate user, from a user who is not the immediate user, from information computers on which data are stored, from medical devices, and from network ports. The method also includes displaying the predicted medical decision(s).

[0109] The method also includes receiving one or more user-decisions. Each user-decision may be a predicted medical decision or may not be a predicted medical decision. The method also includes learning to predict the at least one user-decision from the data received. Learning may include updating one or more learning modules chosen from a group consisting of behavioral models, rule-based algorithms, learning-based algorithms, or neural networks. Learning may further include customizing operations to at least one parameter, such as preferences of a user, habits of a user, medical specialties of a user, patient populations of a user, preferences of a group of users, habits of a group of users, medical specialties of a group of users, and patient populations of a group of users.

[0110] The method may also include, after the step of receiving user-decisions, executing the user-decisions. The method may also include automatically executing the predicted medical decisions, before user-decisions are received. Executing a decision may include changing the state of a computation or process or communicating with an entity external to the system in some manner such as storing the decision, altering a computer display, updating a diagnosis or finding, ordering a medication, ordering a laboratory test, ordering an imaging test, ordering a consultation, retrieving information, displaying an article, changing the control path of a task, asking the user a question, sending information to a user, controlling a medical device, and the like. In an embodiment, the method may provide a "virtual specialist" to a user, by providing information pertaining to at least one medical specialty to the at least one user. The method may also include displaying an electronic medical chart graphical user interface.

[0111] In an exemplary embodiment, the method may be implemented on at least one portable computing device. Alternatively, the method may be implemented on a host computer that receives data transmitted from one or more portable computing devices, which also receive and display output from the host computer.

[0112] An embodiment includes receiving data and transmitting the data to one or more neural networks. One or more medical decisions may be predicted by neural networks, and the predicted medical decisions are displayed. One or more user-decisions are received from the user or users. Each user-decision may be a predicted medical decision or may not be a predicted medical decision. The method also includes learning to predict the user-decisions from the data received, by updating the neural networks.

[0113] Another embodiment is directed to an example in which the learning is based on the decisions of one or more first users who are not the immediate user or users. This embodiment includes receiving one or more first quantities of data and one or more user-decisions from one or more first users. The embodiment includes learning to predict the user-decisions from the first quantities of data received. The embodiment next includes receiving one or more second quantities of data, predicting one or more medical decisions, and displaying the predicted medical decisions. The embodiment includes receiving one or more second user-decisions, but not learning from them.

[0114] Another embodiment is directed to using rule-based algorithms to make predictions while learning develops. This embodiment includes receiving a first quantity of data and using at least one rule-based algorithm to predict one or more first medical decisions. These first medical decisions are displayed. The embodiment includes receiving one or more user-decisions from one or more first users. The method may include executing the user-decisions, after they are received. The embodiment includes learning to predict the user-decisions from the data received. The embodiment may also include executing the first predicted medical decision, before receiving the user-decisions. The embodiment also includes receiving a second quantity of data and using one or more learning-based algorithms to predict one or more second medical decisions. One or more third medical decisions are also predicted by the one or more rule-based algorithms. The method involves displaying the second predicted medical decisions, or the third predicted medical decisions, or both. Which decisions are displayed may be selected automatically by a computing device or by one or more users. The embodiment may also include automatically executing either the second or third predicted medical decisions, or both.

[0115] Users may include different classes of users such as medical doctors, nurses, nurse practitioners, residents, medical students, medical staff, administrative staff, technicians, patients, payers, pharmacy benefits managers, insurance companies, and consultants. In an embodiment of the method, decisions are predicted for a first user or group of users, via the predictive model of a second user or group of users who may be of a different class than the first user.

[0116] The disclosure is also directed to a software program, embodied on a computer-readable medium, incorporating the exemplary method.

[0117] The disclosure is also directed to a computer-based system for adaptively supporting medical decisions of one or more users. The system includes component for receiving data; component for predicting medical decisions; component for receiving at least one user-decision; display component; and component for learning to predict the at least one user-decision, from the data received. The system may include one or more portable computing devices, or it may include both a host computer and one or more portable computing devices. The portable computing devices may be linked or integrated with a medical instrument. Each computing device may communicate with the host computer via a wireless communication component consisting of radio signals, infrared signals, or pulse codes. The component for learning may include one or more learning modules selected from a group consisting of at least one behavioral model, at least one rule-based algorithm, at least one learning-based algorithm, and at least one neural network.

[0118] In a particular embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving a first input from a first device, receiving a second input from a second device, determining a suggested medical decision based at least in part on the first input and the second input, and transferring the suggested medical decision to the second device. In an example, the first device is an automated patient monitoring device, a patient input device or a nurse input device. In another example, the second device is a physician input device. The method may also include receiving a medical decision input from the second device based at least in part on the suggested medical decision. The suggested medical decision may include, for example, a diagnosis, an order, or a prescription. In a further example, transferring includes transferring a user interface including pre-selected interface controls. The first and second devices may be wireless interface devices.

[0119] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving a medical input from a user device, determining a first suggested decision from a first predictive model, determining a second suggested decision from a second predictive model, and transferring the first suggested decision and the second suggested decision to the user device. In an example, the first predictive model is trained based at least in part on input from a group of users. In another example, the first predictive model is associated with a medical specialty. In a further example, the second predictive model is trained based at least in part on inputs received from a particular user of the user device. The user device may be a wireless user interface device.

[0120] In a further exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving a user medical input and a user medical decision from a device, determining a suggested result based at least in part on the user medical input, comparing the user medical decision to the suggested result, and providing an indication based at least in part on comparing the user medical decision to the suggested result. In an example, the user decision may include a coding decision. The suggested result may include a suggested coding decision and providing the indication may include providing a coding alert. In another example, determining the suggested result includes accessing a model. The model may be associated with inputs of a group of users or may be associated with a payer, such as an insurance company or a government entity. In a further example, the model may be associated with instructive practices, such as practices of a physician overseeing medical students.

[0121] In an additional embodiment, a computer-implemented method for adaptively supporting decisions of at least one user includes receiving a set of user inputs, training a model based at least in part on the set of user inputs, and adjusting the model based at least in part on a set of outlier inputs. In an example, the set of user inputs includes a set of findings and a diagnosis based at least in part on the medical findings. The set of outlier inputs may represent a set of unusual diagnoses. In another example, receiving the set of user inputs includes receiving user inputs resulting from consultation with patients. In a further example, adjusting the model includes periodically introducing the set of outlier inputs for training the model.

[0122] In an exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow. The electronic medical record may be implemented on a wireless portable interface device. The method also includes receiving data at a host computer from a second electronic medical record interface associated with a second medical workflow. The second electronic medical record may be implemented on a second interface device. In addition, the method may include predicting at least one medical decision based on the received data, displaying the at least one predicted medical decision via the first electronic medical record interface, and receiving at least one user-decision from the at least one user via the first electronic medical record interface. In an example, each user decision may be a predicted medical decision or may not be a predicted medical decision. The method may also include learning to predict the at least one user decision from the data received. In another example, the second electronic medical record interface is an interface that affords log-in by a patient. In a further example, the medical data received by the host computer from the second interface device travels via a network path that includes the Internet. In an additional example the second electronic medical record interface is an interface that affords log-in by a nurse.

[0123] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow. The electronic medical record may be implemented on a wireless portable interface device. The method also includes receiving medical data at a host computer from a remote computer, predicting at least one medical decision based on the received data, displaying the at least one predicted medical decision via the first electronic medical record interface, and receiving at least one user-decision from the at least one user via the first electronic medical record interface. In an example, each user decision may be a predicted medical decision. The method may also include learning to predict the at least one user decision from the data received. In a further example, the medical data from a remote computer includes medical test result data. In another example, the medical data from a remote computer includes recommended diagnostic questions or tests. Further, the medical data from a remote computer may include treatment orders or medical information about a patient.

[0124] In a further exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow. The electronic medical record may be implemented on a wireless portable interface device. The method may also include predicting at least one medical decision at the host computer based on the received data, displaying the at least one predicted medical decision in the electronic medical record interface implemented on the wireless portable interface device, and receiving at least one user-decision from the at least one user via the electronic medical record interface. Displaying the at least one predicted medical decision may include displaying a selectable item initialized according to at least one predicted medical decision. In an example, the method may include learning to predict the at least one user-decision using the host computer based on the received data and the at least one user-decision. In another example, a selectable item of the electronic medical record interface may be initialized to the selected state. In a further example, the method may include receiving a deselect input and the selectable item transitions to the deselected state. In an additional example, the selectable item may indicate a medication order and the predicted medical decision includes at least one prescribing parameter, and the selectable item is initialized with the at least one predicted prescribing parameter.

[0125] In an additional embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow. The electronic medical record may be implemented on a wireless portable interface device. The method may also include predicting at least one medical decision at the host computer based on the received data, displaying the at least one predicted medical decision in the electronic medical record interface implemented on the wireless portable interface device, receiving at least one user-decision from the at least one user via the electronic medical record interface, and learning to predict the at least one user-decision using the host computer based on the received data and the at least one user-decision. Predicting the at least one medical decision may include combining a first set of predictions that do not depend on past decisions by the user and a second set of predictions that depend on past decisions by the user.

[0126] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow. The electronic medical record may be implemented on a wireless portable interface device. The method may also include predicting at least one medical coding decision at the host computer based on the received data, displaying the at least one predicted medical coding decision in the electronic medical record interface implemented on the wireless portable interface device, and receiving at least one user-decision from the at least one user via the electronic medical record interface. In an example, the method may further includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow, receiving at least one user-decision from at least one additional user via the electronic medical record interface on at least one additional interface device, and learning to predict the at least one user-decision using the host computer based on the received data from the first portable interface device, the received data from at least one additional interface device, the at least one user-decision, and at least one user decision from at least one additional interface device. In an example, the method also includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow. The electronic medical record may be implemented on at least one additional interface device. In another example, the method may include receiving at least one user-decision from at least one additional user via the electronic medical record interface on at least one additional interface device and learning to predict the at least one user-decision using the host computer based on the received data from at least one additional interface device and at least one user decision from at least one additional interface device. In a further example, the method may include displaying a comparison of the at least one user-decision and the predicted decision. In another example, the method may include storing past user-decisions and displaying a comparison of past user-decisions with predicted decisions. In a further example, the method may include notifying a user whose past user-decisions comprise higher codes than predicted decisions. In an additional example, the method may include notifying a user whose past user-decisions comprise lower codes than predicted decisions. In another embodiment, the method may include receiving data at a host computer from an electronic medical record interface associated with a medical workflow, receiving at least one user-decision from at least one additional user via the electronic medical record interface on at least one additional interface device, storing past user-decisions from the first user and from at least one additional user, and simultaneously displaying information relating to past user decisions for at least two users. Further, displaying the at least one predicted medical coding decision may include displaying at least one additional diagnostic finding that may be selected or test that may be ordered.

[0127] In a further embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow, predicting at least one medical decision at the host computer based on the received data and one of at least two predictive models, displaying the at least one predicted medical decision in the electronic medical record interface implemented on the wireless portable interface device, and receiving at least one user-decision from the at least one user via the electronic medical record interface. In an example, the interface device affords selection of a patient and that a first predictive model is used to predict medical decisions regarding a first patient and a second predictive model is used to predict medical decisions regarding a second patient. In another example, the at least two predictive models are stored on the host computer and the predicting of at least one medical decision is done at the host computer. In a further example, the method includes receiving at least one predictive model from a first remote computer, receiving a second predictive model from a second remote computer and storing the received predictive models on a host computer.

[0128] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow, storing at at least one prediction computer at least one predictive model, transmitting medical data from a host computer to a prediction computer, receiving medical data at a host computer, predicting at least one medical decision at the prediction computer based on the received medical data and one of at least one predictive model, transmitting at least one prediction from the prediction computer to the host computer, displaying the at least one predicted medical decision in the electronic medical record interface implemented on the wireless portable interface device, and receiving at least one user-decision from the at least one user via the electronic medical record interface. In an example, predicting includes predicting at least one medical decision based on the received data and one of at least two predictive models. In another example, transmitting data from a host computer to a prediction computer includes selecting a prediction computer from a set of at least two prediction computers. In addition, a first prediction computer stores a first prediction model and a second prediction computer stores a second prediction model.

[0129] In an additional embodiment, a computer-implemented method for evaluating medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow, predicting at least one medical decision at the host computer based on the received data, displaying the at least one predicted medical decision in the electronic medical record interface implemented on the wireless portable interface device, receiving at least one user-decision from the at least one user via the electronic medical record interface, and storing past user-decisions and displaying a comparison of past user-decisions with predicted decisions. In an example, the method further includes displaying a notification that a predicted action was omitted in at least one instance. In another example, the predicted action is one of the following types of action: to refer the patient to a disease management program, to prescribe a specific medication for the patient, to prescribe a medication from a specific class of medications for the patient. In a further example, the notification is displayed on a second interface device to a second user.

[0130] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user including receiving data at a host computer from an electronic medical record interface associated with a medical workflow, predicting at least one medical decision at the host computer based on the received data, displaying the at least one predicted medical decision in the electronic medical record interface implemented on the wireless portable interface device, receiving at least one user-decision from the at least one user via the electronic medical record interface; and learning to predict the at least one user-decision using the host computer based on the received data and the at least one user-decision. In an example, the host computer function and the interface device function reside on the same computer device. In another example, the predicted medical decision is to select a diagnosis. In a further example, the predicted medical decision is to order a medication. In an additional example, the predicted medical decision is to order a test. In another example, the predicted medical decision is to order a procedure.

[0131] In a further exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow, predicting at least one medical decision at the host computer based on the received data, displaying the at least one predicted medical decision in the electronic medical record interface implemented on the wireless portable interface device, receiving at least one user-decision from the at least one user via the electronic medical record interface, learning to predict the at least one user-decision using the host computer based on the received data and the at least one user-decision, and transmitting at least one user decision to a remote computer via a network. In an example, the user decision is transmitted to a remote computer via a network path that comprises a wireless network. In another example, the user decision is transmitted to a remote computer via a network path that comprises the Internet.

[0132] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving at least one first quantity of computer readable data associated with a medical workflow, receiving at least one user-decision associated with the medical workflow via an electronic medical records interface, learning to predict the at least one received user-decision based on the at least one first quantity of computer readable data and the at least one user-decision by adapting a computer implemented prediction model, receiving at least one second quantity of computer readable data associated with the medical workflow, predicting at least one medical decision based on the at least one second quantity of computer readable data using the computer implemented prediction model, the at least one medical decision being associated with the medical workflow, displaying the at least one predicted medical decision via the electronic medical records interface, receiving at least one second user-decision associated with the medical workflow via the electronic medical records interface, and storing at least one user-decision in at least one computer readable medium. In an example, at least one user decision is to record a medical finding about the condition of a patient. In another example, at least one user decision is to issue an order regarding patient treatment. In a further example, the method includes a first user logging into the system using a first identity, a second user logging into the system using a second identity, the system receiving the first at least one user decision from a logical session associated with the first user, and the system receiving the second at least one user decision from a logical session associated with the second user. In an additional example, the method further includes a first plurality of login sessions associated with a first plurality of user identities, a second login session associated with a user identity, the system receiving the first at least one user decision from the first plurality of login sessions, and the system receiving the second at least one user decision from a logical session associated with the second user login session.

[0133] In an exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions includes receiving a first quantity of computer readable data associated with a medical workflow, predicting a first at least one medical decision associated with the medical workflow based on the computer readable data, via at least one prediction algorithm, displaying the first at least one medical decision in an electronic medical interface, receiving at least one user-decision associated with the medical workflow from a first at least one user via the electronic medical interface, learning to predict the at least one user-decision based on the at least one user-decisions and the computer readable data wherein learning to predict the at least one user-decisions includes adapting the at least one prediction algorithm, receiving a second quantity of computer readable data associated with the medical workflow via the electronic medical interface, predicting via at least one learning-based algorithm a second at least one medical decision associated with the medical workflow based on the second quantity of computer readable data, and storing at least one user-decision in at least one computer readable medium.

[0134] In a further exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a host computer from an electronic medical record interface associated with a medical workflow wherein the electronic medical record is implemented on a wireless portable interface device, predicting at least one medical decision at the host computer based on the received data, displaying the at least one predicted medical decision in the electronic medical record interface implemented on the wireless portable interface device, receiving at least one user-decision from the at least one user via the electronic medical record interface, receiving a plurality of training sets, each of data and at least one user-decision from a remote computer, and learning to predict the at least one user-decision using the host computer based on the training sets, received data, and the at least one user-decision. In an example, the training sets include at least one example of at least one rare medical decision.

[0135] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving at least one first quantity of computer readable data associated with a medical workflow, receiving at least one user-decision associated with the medical workflow via an electronic medical records interface, learning to predict the at least one first quantity of computer readable data based on at least one user-decision by adapting a computer implemented prediction model, receiving at least one second quantity of computer readable data associated with the medical workflow, receiving at least one second user-decision associated with the medical workflow via the electronic medical records interface, predicting a third quantity of computer readable data associated with the medical workflow based on the second user-decision, and comparing the predicted third quantity of computer readable data to the received second quantity of computer readable data. In an example, the method includes displaying information relating to the comparison. In another example, the method further includes notifying the user of outlier findings present in the second quantity of data but not predicted by the prediction algorithm.

[0136] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes providing an electronic medical record interface affording log-in by a first group of users, receiving medical data regarding each patient in a plurality of patients at a host computer, receiving at least one user decision regarding each patient in the plurality of patients from at least one user of the first group of users via an electronic medical record interface, generating a predictive model that predicts one or more user decisions from data regarding a patient based on the received medical data and the received at least one user decision, providing an electronic medical record interface affording log-in by a second group of users, receiving medical data regarding a patient, using the predictive model to predict a decision from the medical data regarding a patient, displaying this prediction via an electronic medical record interface via a log-in session associated with a user from the second group of users. In an example, the method includes receiving a user-decision via an electronic medical record interface via a log-in session associated with a user from the second group of users.

[0137] In a further embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes providing an electronic medical record interface affording log-in by a first group of users, receiving medical data regarding each patient in a plurality of patients at a host computer, receiving at least one user decision regarding each patient in the plurality of patients from at least one user of the first group of users via an electronic medical record interface, generating a predictive model that predicts one or more user decisions from data regarding a patient based on the received medical data and the received at least one user decision, providing an electronic medical record interface affording log-in by a second group of users, receiving medical data regarding a patient, using the predictive model to predict a decision from the medical data regarding a patient, receiving a user-decision via an electronic medical record interface via a log-in session associated with a user from the second group of users, and displaying information comparing the received user-decision and the predicted decision. In an example, displaying information comparing the received user-decision and the predicted decision includes alerting the user if the decisions differ.

[0138] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes providing an electronic medical record interface affording log-in by a first group of users, receiving medical data regarding at least one patient from at least one user of the first group of users via an electronic medical record interface, providing an electronic medical record interface affording log-in by a second group of users, receiving medical data regarding a patient from a second at least one user of the second group of users via an electronic medical record interface, predicting at least one user decision based on the medical data entered by the first at least one user and on the medical data entered by the second at least one user, and displaying the predicted decision via an electronic medical record interface via a log-in session associated with a user from the second group of users. In an example, the method also includes receiving a user-decision via an electronic medical record interface via a log-in session associated with a user from the second group of users. In another example, the method also includes adapting the prediction means based on the received user decision.

[0139] In a further exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving data at a prediction computer from an electronic medical record interface associated with a medical workflow wherein the electronic medical record implemented on an interface device, predicting at least one medical decision at the prediction computer based on the received data, displaying the at least one predicted medical decision in the electronic medical record interface implemented on the interface device, receiving at least one user-decision from the at least one user via the electronic medical record interface, and learning to predict the at least one user-decision using the prediction computer based on the received data and the at least one user-decision. In an example, receiving data further includes receiving data via a network communication means. In another example, executing the at least one user-decision, after the step of receiving 1the at least one user-decision. In a further example, the method also includes executing the at least one predicted medical decision, before the step of receiving the at least one user-decision.

[0140] In another exemplary embodiment, a computer-implemented method for adaptively supporting medical decisions of at least one user includes receiving at least one first quantity of computer readable data associated with a medical workflow, receiving at least one user-decision associated with the medical workflow from a first at least one user via an electronic medical records interface, learning to predict the at least one received user-decision based on the at least one first quantity of computer readable data and the at least one user-decision by adapting a computer implemented prediction model, receiving at least one second quantity of computer readable data associated with the medical workflow, predicting at least one medical decision based on the at least one second quantity of computer readable data using the computer implemented prediction model, the at least one medical decision being associated with the medical workflow, displaying the at least one predicted medical decision via the electronic medical records interface, and receiving at least one second user-decision associated with the medical workflow via the electronic medical records interface. In an example, receiving the at least one second quantity of computer readable data further includes receiving data via a network communication method. In an example, the method is implemented on at least one portable computing device. In another example, receiving and predicting are implemented on at least one host computer, the host computer receives data from at least one portable computing device, and the at least one portable computing device receives and displays output from the host computer. In a further example, executing the at least one user-decision, after the step of receiving the at least one user-decision. In another example, the method further includes automatically executing the at least one predicted medical decision, before the step of receiving the at least one user-decision. In addition, the first at least one user may include a specialist in a field of medicine or a billing specialist or a coding specialist. In another example, the second at least one decision is received from a second at least one user with a log-in identity to the electronic medical records interface that is distinct from the log-in identity of the first at least one user. In a further example, the displayed at least one medical decision is displayed in a different language than the first received user decision. In another example, displaying the at least one medical decision comprises displaying information relating to prescriptions issued by another user. In a further example, displaying the at least one medical decision comprises displaying a warning that a prescription being issued conflicts with another prescription issued. In an additional example, displaying the at least one medical decision includes displaying a warning that a prescription being issued is redundant with another prescription issued by a different user.

[0141] In an additional embodiment, a computer-implemented method for adaptively supporting medical decisions includes receiving a first quantity of computer readable data associated with a medical workflow, predicting a first at least one medical decision associated with the medical workflow based on the computer readable data, via at least one prediction algorithm, displaying the first at least one medical decision in an electronic medical interface, receiving at least one user-decision associated with the medical workflow from a first at least one user via the electronic medical interface, learning to predict the at least one user-decision based on the at least one user-decisions and the computer readable data, wherein learning to predict the at least one user-decisions includes adapting via the at least one learning algorithm, receiving a second quantity of computer readable data associated with the medical workflow via the electronic medical interface, and predicting via at least one learning-based algorithm a second at least one medical decision associated with the medical workflow based on the second quantity of computer readable data. In an example, the method also includes displaying the second at least one medical decision. In a further example, receiving the second quantity of computer readable data further includes receiving the second quantity of computer readable data via a network communication method. In an additional example, receiving a first quantity of data, predicting a decision, and learning to predict are implemented on a host computer, the host computer receives data from at least one portable computing device, and the at least one portable computing device receives and displays output from the host computer. In another example, the method includes executing the first at least one medical decision, before receiving the at least one user-decision. In a further example, the method includes receiving a second at least one user-decision, after predicting the second at least one medical decision. In an example, the method includes executing the second at least one user-decision after receiving the second at least one user-decision. In a further example, learning further includes updating at least one learning module chosen from a group consisting of behavioral models, rule-based algorithms, learning-based algorithms, and neural networks. In another example, learning further includes customizing a plurality of operations to at least one parameter chosen from a group consisting of preferences of a user, habits of a user, medical specialties of a user, patient populations of a user, preferences of a group of users, habits of a group of users, medical specialties of a group of users, and patient populations of a group of users. In a further example, the method further includes predicting via the at least one rule-based algorithm a third at least one medical decision and displaying at least one predicted medical decision chosen from a group consisting of the second at least one medical decision, the third at least one medical decision, and both the second and third at least one medical decisions. In another example, the method includes executing the predicted medical decision chosen from the group consisting of the second at least one medical decision, the third at least one medical decision, and both the second and third at least one medical decision. In a further example, the predicted medical decision chosen from the group consisting of the second at least one medical decision, the third at least one medical decision is selected by at least one user, and both the second and third at least one medical decisions, is selected by at least one user. In an example, the predicted medical decision chosen from the group consisting of the second at least one medical decision, the third at least one medical decision, and both the second and third at least one medical decision, is selected by a computing device. In a further example, the method includes receiving a second at least one user-decision, after predicting the third at least one medical decision. In another example, the method includes executing the second at least one user-decision after receiving the second at least one user-decision. In an example, the method further includes learning to predict the second user-decision from the second quantity of data received. In a further example, learning further includes updating at least one learning module chosen from a group consisting of behavioral models, rule-based algorithms, learning-based algorithms, and neural networks. In another example, learning further includes customizing a plurality of operations to at least one parameter chosen from a group consisting of preferences of a user, habits of a user, medical specialties of a user, patient populations of a user, preferences of a group of users, habits of a group of users, medical specialties of a group of users, and patient populations of a group of users. In an example, the method further includes displaying an electronic medical chart user interface. In another example, the first at least one user is a specialist in a field of medicine or a billing specialist or a coding specialist.

[0142] In a further exemplary embodiment, a computer-implemented method for adaptively supporting decisions of at least one user includes receiving at least one first quantity of computer readable data associated with a workflow in which one or more users record information about a subject and make and act on decisions, receiving at least one user-decision associated with the workflow from a first at least one user via an electronic records interface, learning to predict the at least one received user-decision based on the at least one first quantity of computer readable data and the at least one user-decision by adapting a computer implemented prediction model, receiving at least one second quantity of computer readable data associated with the workflow, predicting at least one decision based on the at least one second quantity of computer readable data using the computer implemented prediction model, the at least one decision being associated with the workflow, displaying the at least one predicted decision via the electronic records interface, and receiving at least one second user-decision associated with the workflow via the electronic records interface. In an example, the workflow is an auto repair workflow, a law-enforcement workflow, an emergency-response workflow, a customer service workflow, or a computer repair workflow.

[0143] Using the foregoing, systems and methods may be implemented using standard programming or engineering techniques including computer programming software, firmware, hardware or any combination or subset thereof Any such resulting program, having a computer readable program code component, may be embodied or provided within one or more computer readable or usable media, thereby making a computer program product, i.e. an article of manufacture, according to the invention. The computer readable media may be, for example, a fixed (hard) drive, disk, diskette, optical disk, magnetic tape, semiconductor memory such as read-only memory (ROM), or a transmitting/receiving medium, such as the Internet or other communication network or link. The article of manufacture including the computer programming code may be made and/or used by executing the code directly from one medium, by copying the code from one medium to another medium, or by transmitting the code over a network.

[0144] An apparatus for making, using or selling the invention may be one or more processing systems including, but not limited to, a central processing unit (CPU), memory, storage devices, communication links, communication devices, server, I/O devices, or any sub-components or individual parts of one or more processing systems, including software, firmware, hardware or any combination or subset thereof, which embody the systems and methods as set forth in the claims.

[0145] User input may be received from the keyboard, mouse, pen, voice, touch screen, or any other component by which a human can input data to a computer, including through other programs such as application programs.

[0146] It may be apparent that the methods described here in the context of a medical workflow may be equally applicable in any context in which one or more users record information about a subject and make and act on decisions that are based on information learned about a subject. Examples of such workflows include auto repair, law enforcement, emergency response, customer service, and computer repair.

[0147] In accordance with various embodiments, the methods described herein may be implemented as one or more software programs running on a computer processor. Dedicated hardware implementations including, but not limited to, application specific integrated circuits, programmable logic arrays and other hardware devices can likewise be constructed to implement the methods described herein. Further, alternative software implementations including, but not limited to, distributed processing or component/object distributed processing, parallel processing, or virtual machine processing can also be constructed to implement methods described herein.

[0148] It should also be noted that software that implements the disclosed methods may optionally be stored on a tangible storage medium, such as: a magnetic medium, such as a disk or tape; a magneto-optical or optical medium, such as a disk; or a solid state medium, such as a memory card or other package that houses one or more read-only (non-volatile) memories, random access memories, or other re-writable (volatile) memories. The software may also utilize a signal containing computer instructions. A digital file attachment to e-mail or other self-contained information archive or set of archives is considered a distribution medium equivalent to a tangible storage medium. Accordingly, the disclosure is considered to include a tangible storage medium or distribution medium as listed herein, and other equivalents and successor media, in which the software implementations herein may be stored.

[0149] Although the present specification describes components and functions that may be implemented in particular embodiments with reference to particular standards and protocols, the invention is not limited to such standards and protocols. For example, wireless communication protocols, such as IEEE 802.11, IEEE 802.15, and IEEE 802.16, represent examples of the state of the art. Such standards are periodically superseded by faster or more efficient equivalents having essentially the same functions. Accordingly, replacement standards and protocols having the same or similar functions as those disclosed herein are considered equivalents thereof.

[0150] One or more embodiments of the disclosure may be referred to herein, individually and/or collectively, by the term "invention" merely for convenience and without intending to voluntarily limit the scope of this application to any particular invention or inventive concept. Moreover, although specific embodiments have been illustrated and described herein, it should be appreciated that any subsequent arrangement designed to achieve the same or similar purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all subsequent adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the description.

[0151] The Abstract of the Disclosure is provided to comply with 37 C.F.R. §1.72(b) and is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, various features may be grouped together or described in a single embodiment for the purpose of streamlining the disclosure. This disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter may be directed to less than all of the features of any of the disclosed embodiments. Thus, the following claims are incorporated into the Detailed Description, with each claim standing on its own as defining separately claimed subject matter.

[0152] The descriptions of **FIGS. 1-12** are provided for illustrative purposes only, and are not meant to be limiting to the present invention. Although the present invention has been described in detail with reference to certain embodiments, it should be apparent that modifications and adaptations to those embodiments may occur to persons skilled in the art without departing from the spirit and scope of the present invention as set forth in the following claims.

1. A computer-implemented method for adaptively supporting medical decisions of at least one user, the method comprising:

receiving a first input from a first device;

receiving a second input from a second device;

determining a suggested medical decision based at least in part on the first input and the second input; and

transfer the suggested medical decision to the second device.

2. The method of claim 1, wherein the first device is an automated patient monitoring device.

3. The method of claim 1, wherein the first device is a patient input device.

4. The method of claim 1, wherein the first device is a nurse input device.

5. The method of claim 1, wherein the second device is a physician input device.

6. The method of claim 1, further comprising receiving a medical decision input from the second device based at least in part on the suggested medical decision.

7. The method of claim 1, wherein the suggested medical decision includes a diagnosis.

8. The method of claim 1, wherein the suggested medical decision includes an order.

9. (canceled)

10. The method of claim 1, wherein transferring includes transferring a user interface including pre-selected interface controls.

11. The method of claim 1, wherein the second device includes a wireless user interface device.

12. A computer-implemented method for adaptively supporting medical decisions of at least one user, the method comprising:

receiving a medical input from a user device;

determining a fist suggested decision from a first model;

determining a second suggested decision from a second model; and

transferring the first suggested decision and the second suggested decision to the user device.

13. The method of claim 12, wherein the first model is trained based on input from a group of users.

14. The method of claim 12, wherein the first model is associated with a particular medical specialty.

15. The method of claim 12, wherein the second model is trained based on inputs received from a particular user of the user device.

16. The method of claim 12, wherein transferring included transferring a user interface including pre-selected interface controls associated with at least one of the first suggested decision and the second suggested decision.

17. The method of claim 12, wherein the user device includes a wireless user interface device.

18. A computer-implemented method for adaptively supporting medical decisions of at least one user, the method comprising:

receiving a medical input and a medical decision from a device;

determining a suggested result based at least in part on the medical input;

comparing the medical decision to the suggested result; and

providing an indication based at least in part on comparing the medical decision to the suggested result.

19. The method of claim 18, wherein the medical decision includes a coding decision.

20. The method of claim 19, wherein the suggested result includes a suggested coding decision, and wherein providing the indication includes providing a coding alert.

21. The method of claim 18, wherein determining the suggested result includes accessing a model.

22. (canceled)

23. (canceled)

24. (canceled)

25. (canceled)

26. (canceled)

27. (canceled)

28. (canceled)

29. (canceled)

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