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Berajawala et al.

(54) **COLLABORATIVE CREATION OF ANNOTATION TRAINING DATA**

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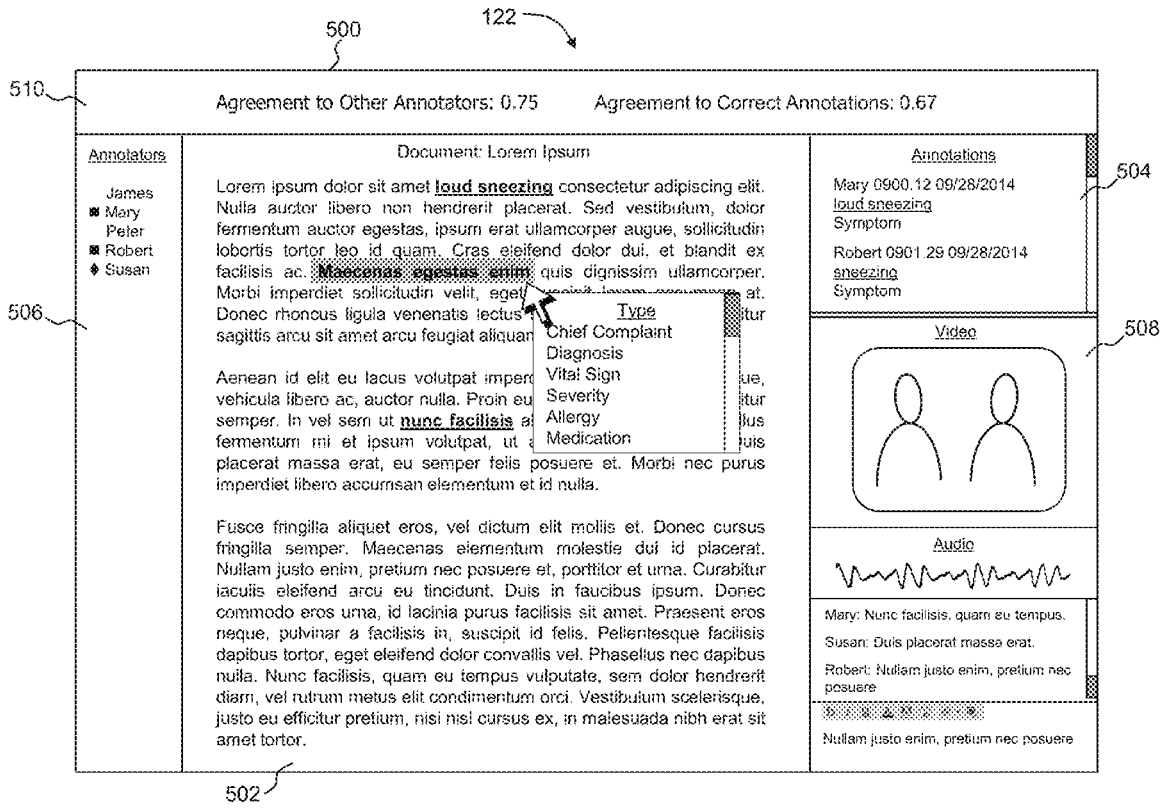
(57) **ABSTRACT**

Collaborative annotation of a document. A GUI is generated by a host computer that displays a document to annotate. The GUI is transmitted by the host computer to a plurality of client computers. Real time communication modes are established by the host computer between the client computers, each including communication channels between all the client computers. The host computer receives annotations entered into the GUIs at the client computers, each annotation identifying a span of words in the document to annotate and including an associated annotation type. The host computer updates the GUI to include for display the received annotations and inter-rater agreement statistics indicating the level of agreement between annotations received from each client computer and annotations received from the other client computers. The updated GUI is then transmitted by the host computer to the plurality of client computers.



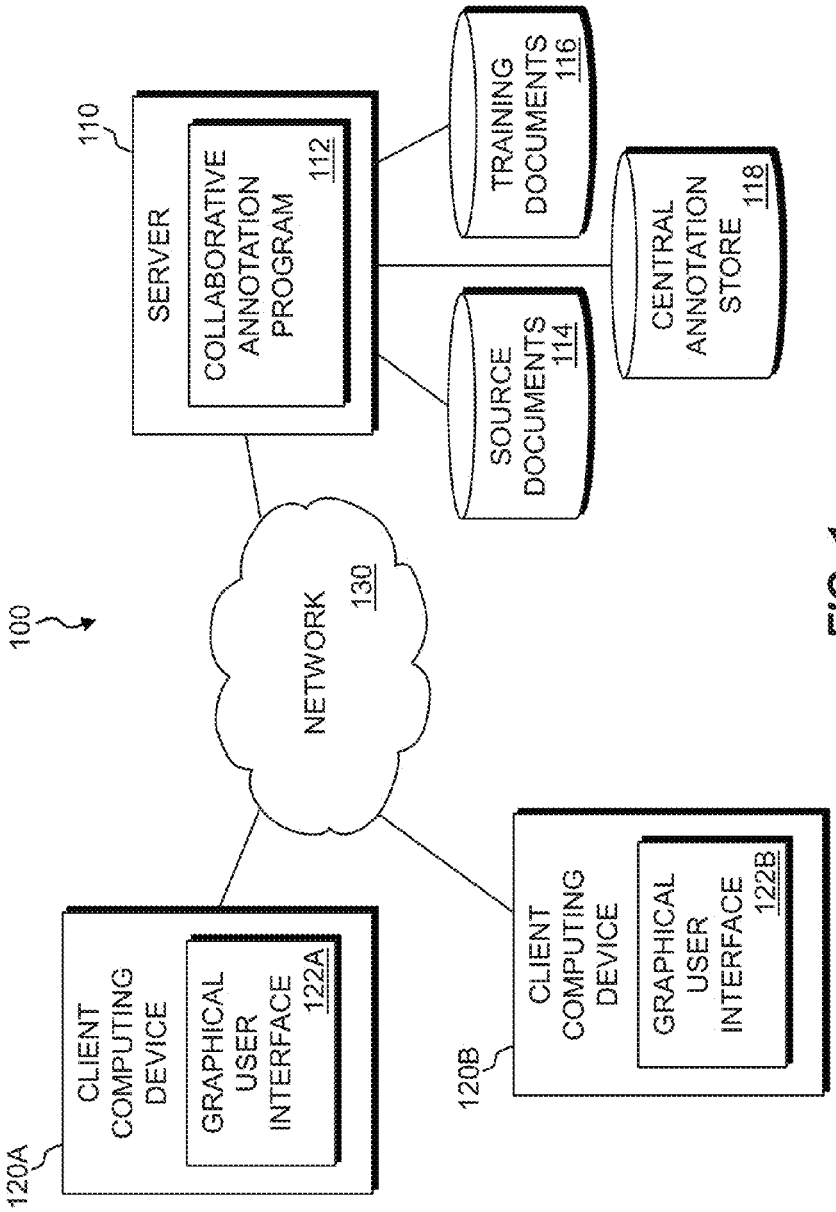
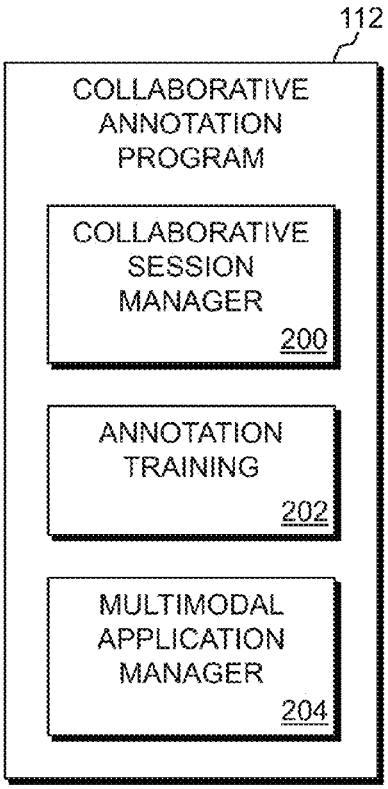

100
110
SERVER
COLLABORATIVE ANNOTATION PROGRAM
112
TRAINING DOCUMENTS
116
CENTRAL ANNOTATION STORE
118
SOURCE DOCUMENTS
114
NETWORK
130
120A
CLIENT COMPUTING DEVICE
GRAPHICAL USER INTERFACE
122A
120B
CLIENT COMPUTING DEVICE
GRAPHICAL USER INTERFACE
122B

FIG. 1


112
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COLLABORATIVE SESSION MANAGER 200
ANNOTATION TRAINING 202
MULTIMODAL APPLICATION MANAGER 204

FIG. 2

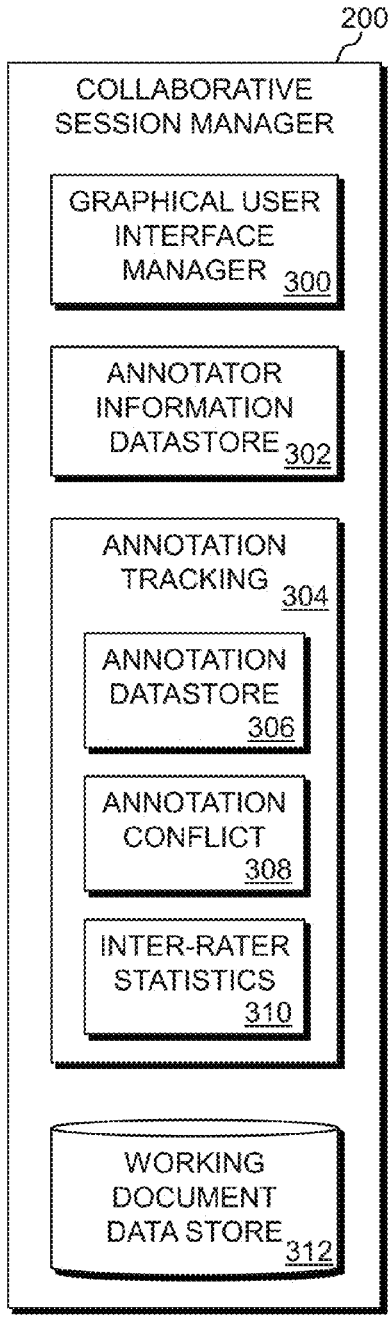
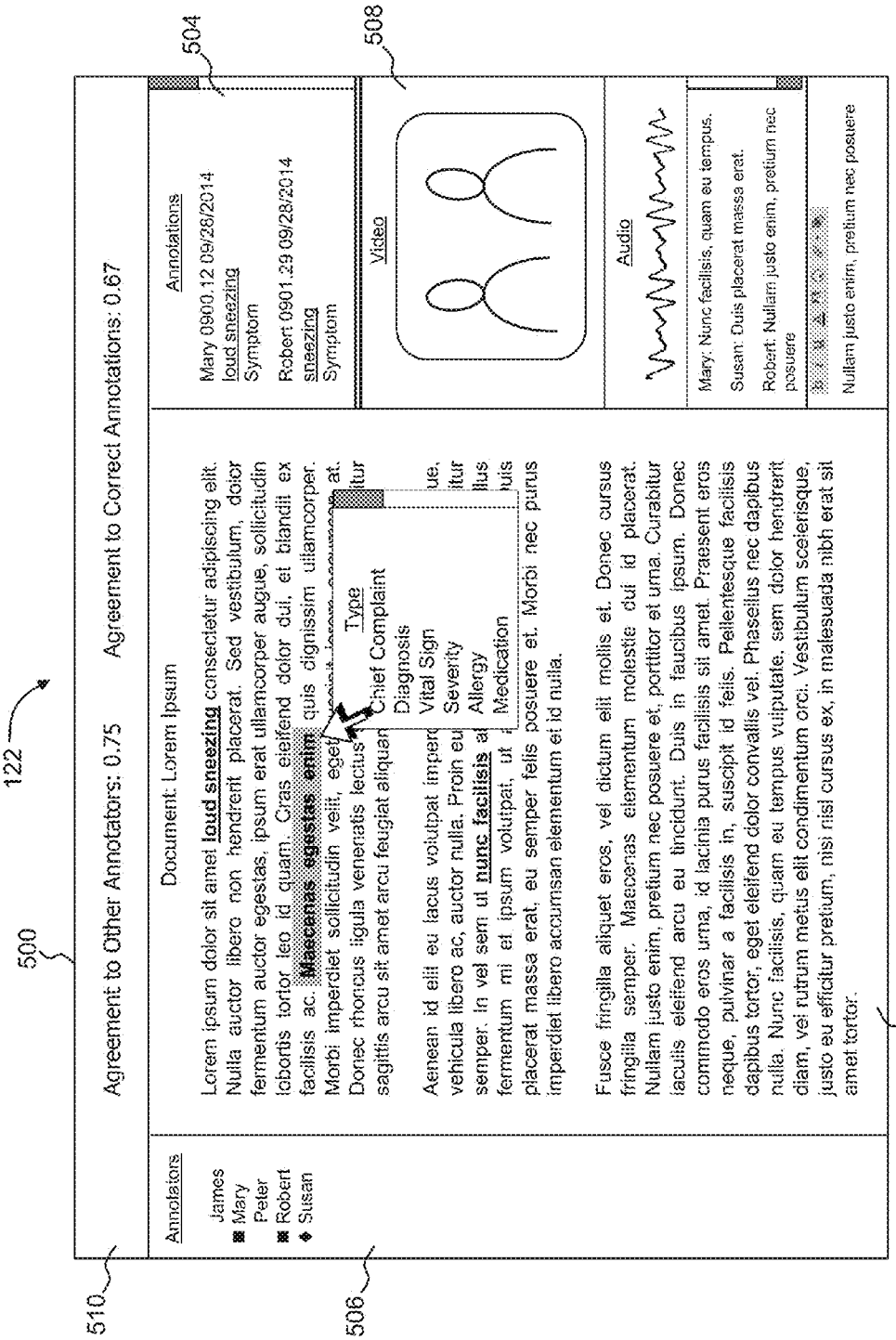

200
COLLABORATIVE SESSION MANAGER
GRAPHICAL USER INTERFACE MANAGER 300
ANNOTATOR INFORMATION DATASTORE 302
ANNOTATION TRACKING 304
ANNOTATION DATASTORE 306
ANNOTATION CONFLICT 308
INTER-RATER STATISTICS 310
WORKING DOCUMENT DATA STORE 312

FIG. 3

306

ANNR ID	TIME	SPAN(S)	TYPE
MARY	0900.12	122:124	ChiefComplaint
ROBERT	0901.29	123:125 133:133	LocationOf
SUSAN	0914.48	166:171	VitalSign

FIG. 4


500
122
Agreement to Other Annotators: 0.75
Agreement to Correct Annotations: 0.67
Annotators
James
Mary
Peter
Robert
Susan
Document: Lorem Ipsum
Lorem ipsum dolor sit amet loud sneezing consectetur adipiscing elit. Nulla auctor libero non hendrerit placerat. Sed vestibulum, dolor fermentum auctor egestas, ipsum erat ullamcorper augue, sollicitudin lobortis tortor leo id quam. Cras eleifend dolor dui, et blandit ex facilisis ac. Maecenas egestas enim quis dignissim ullamcorper. Morbi imperdiet sollicitudin velit, eget
Donec rhoncus ligula venenatis lectus
sagittis arcu sit amet arcu feugiat aliquan
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Chief Complaint
Diagnosis
Vital Sign
Severity
Allergy
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Annotations
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Video
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Mary: Nunc facilisis, quam eu tempus.
Susan: Duis placerat massa erat.
Robert: Nullam justo enim, pretium nec posuere
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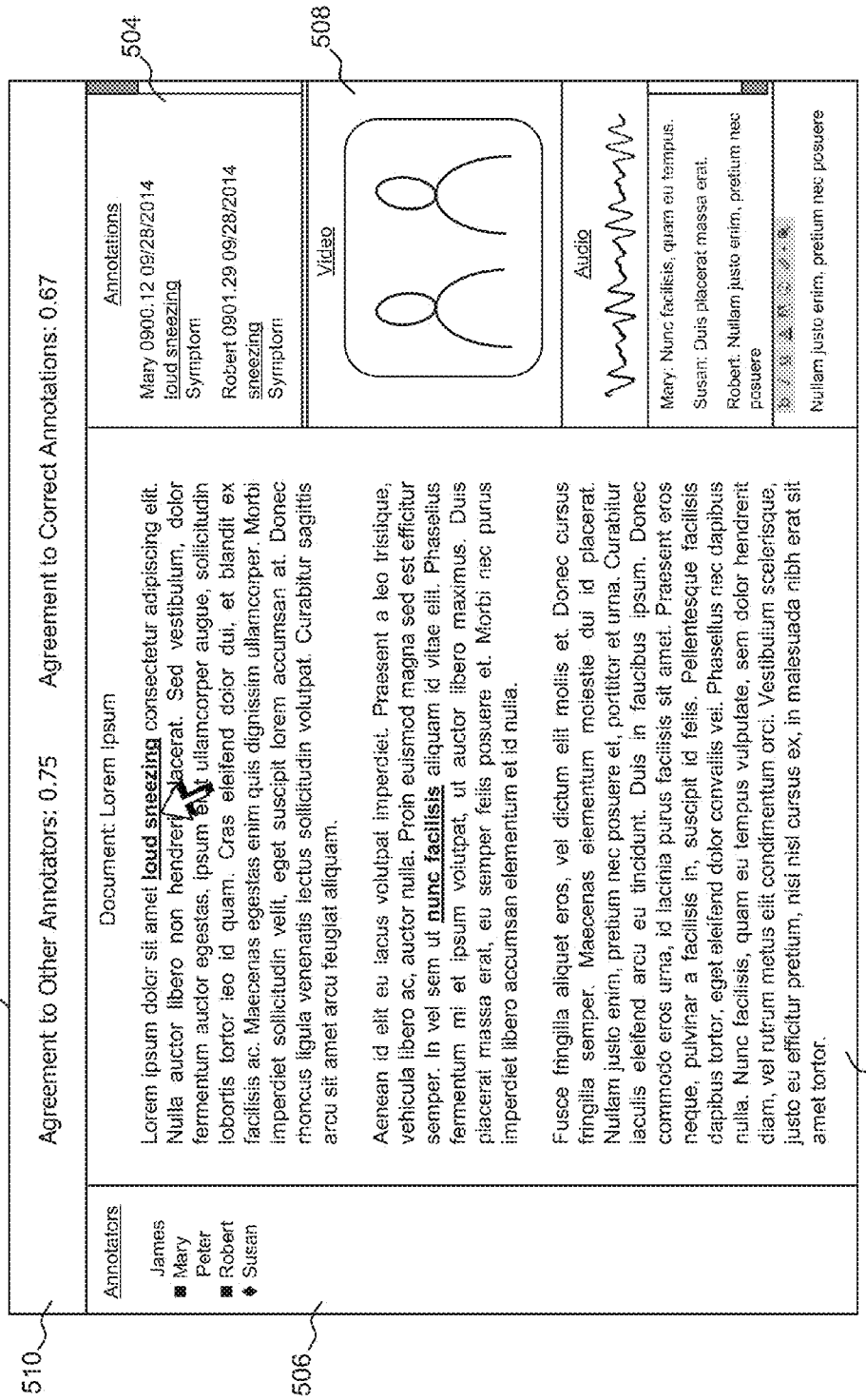
FIG. 5A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Agreement to Other Annotators: 0.75
Agreement to Correct Annotations: 0.67
Annotators
James
Mary
Peter
Robert
Susan
Document: Lorem Ipsum
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Mary: Nunc facilisis, quam eu tempus.
Susan: Duis placerat massa erat.
Robert: Nullam justo enim, pretium nec posuere
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FIG. 5B

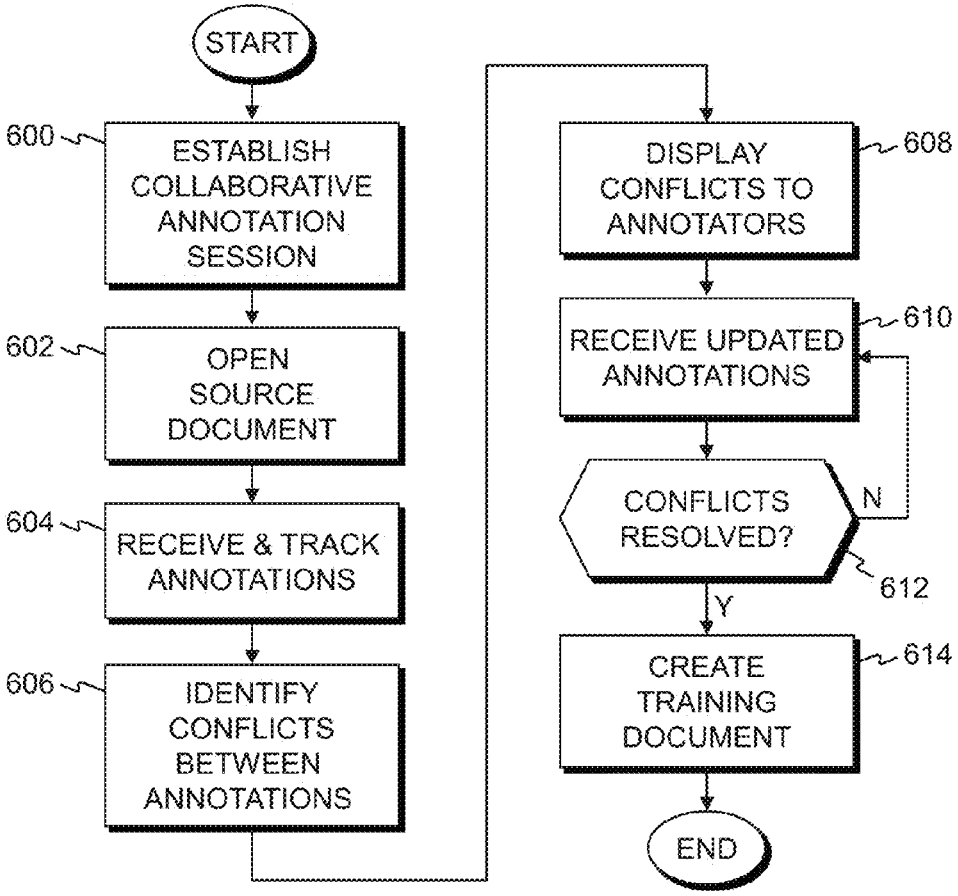
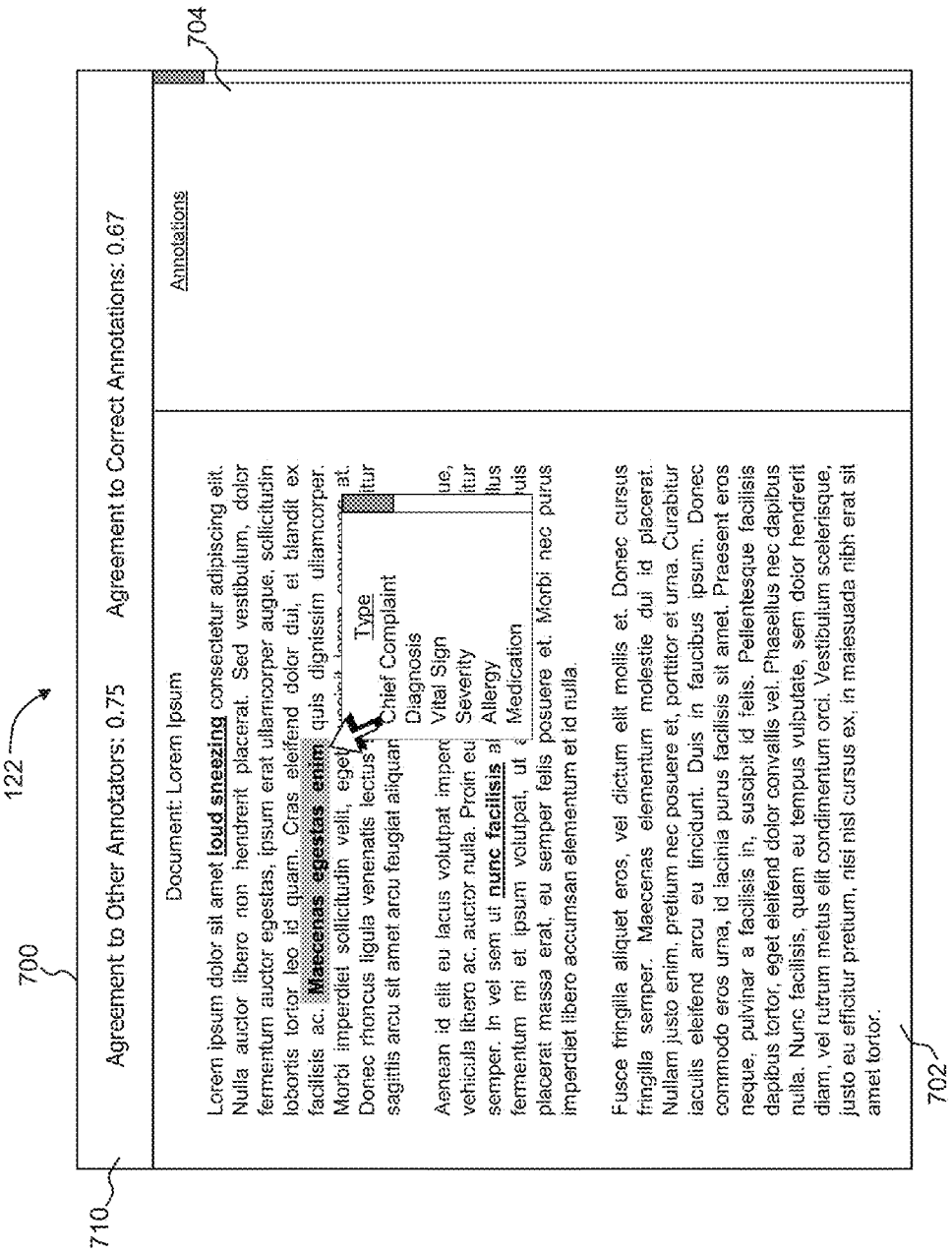

START
600
ESTABLISH COLLABORATIVE ANNOTATION SESSION
602
OPEN SOURCE DOCUMENT
604
RECEIVE & TRACK ANNOTATIONS
606
IDENTIFY CONFLICTS BETWEEN ANNOTATIONS
608
DISPLAY CONFLICTS TO ANNOTATORS
610
RECEIVE UPDATED ANNOTATIONS
CONFLICTS RESOLVED?
N
612
Y
614
CREATE TRAINING DOCUMENT
END

FIG. 6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Agreement to Other Annotators: 0.75
Agreement to Correct Annotations: 0.67
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sagittis arcu sit amet arcu feugiat aliquan
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Allergy
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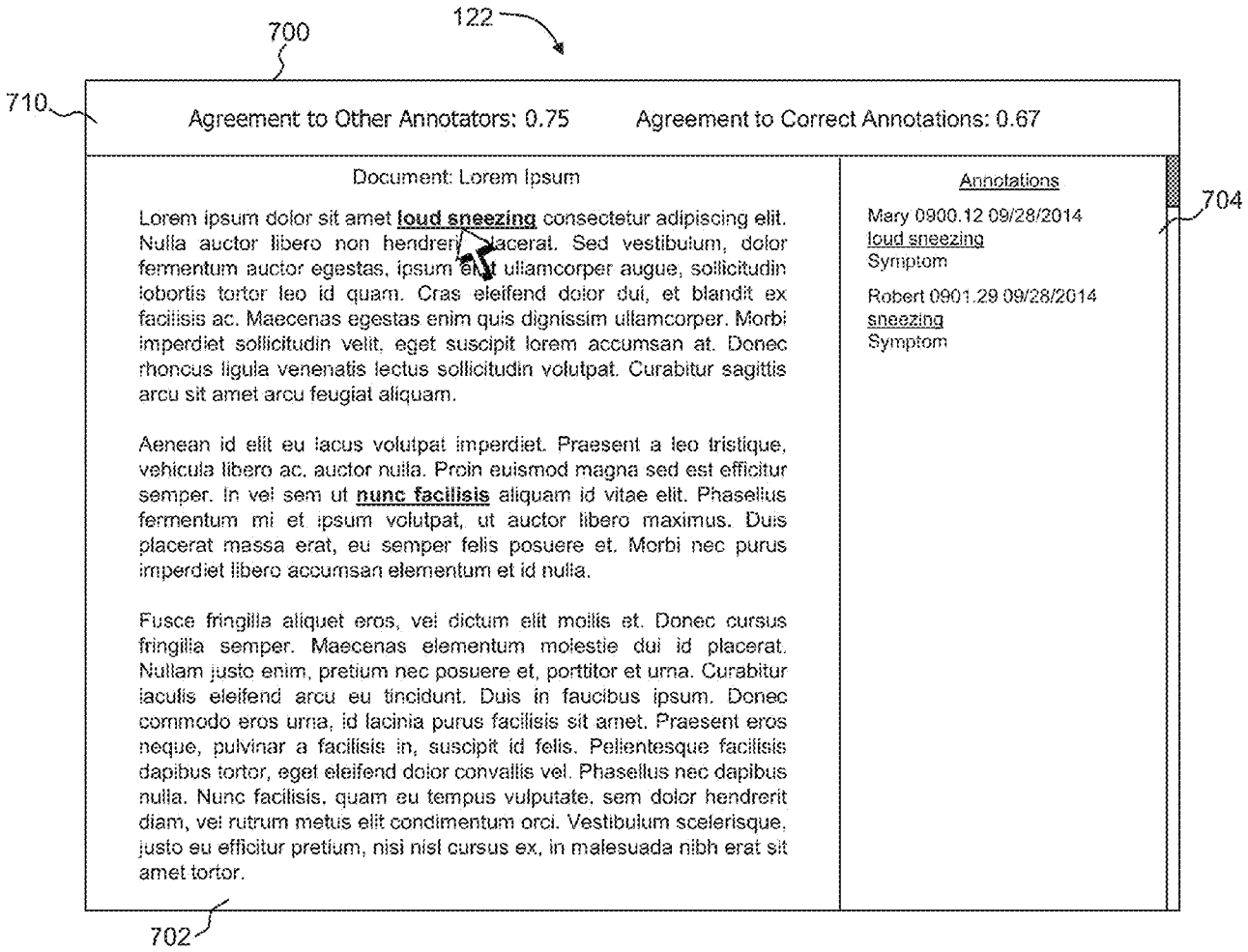
FIG. 7A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Agreement to Other Annotators: 0.75
Agreement to Correct Annotations: 0.67
Document: Lorem Ipsum
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Aenean id elit eu lacus volutpat imperdiet. Praesent a leo tristique, vehicula libero ac, auctor nulla. Proin euismod magna sed est efficitur semper. In vel sem ut nunc facilisis aliquam id vitae elit. Phasellus fermentum mi et ipsum volutpat, ut auctor libero maximus. Duis placerat massa erat, eu semper felis posuere et. Morbi nec purus imperdiet libero accumsan elementum et id nulla.
Fusce fringilla aliquet eros, vel dictum elit mollis et. Donec cursus fringilla semper. Maecenas elementum molestie dui id placerat. Nullam justo enim, pretium nec posuere et, porttitor et urna. Curabitur iaculis eleifend arcu eu tincidunt. Duis in faucibus ipsum. Donec commodo eros urna, id lacinia purus facilisis sit amet. Praesent eros neque, pulvinar a facilisis in, suscipit id felis. Pellentesque facilisis dapibus tortor, eget eleifend dolor convallis vel. Phasellus nec dapibus nulla. Nunc facilisis, quam eu tempus vulputate, sem dolor hendrerit diam, vel rutrum metus elit condimentum orci. Vestibulum scelerisque, justo eu efficitur pretium, nisi nisl cursus ex, in malesuada nibh erat sit amet tortor.
Annotations
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Symptom
Robert 0901.29 09/28/2014
sneezing
Symptom
704
702

FIG. 7B

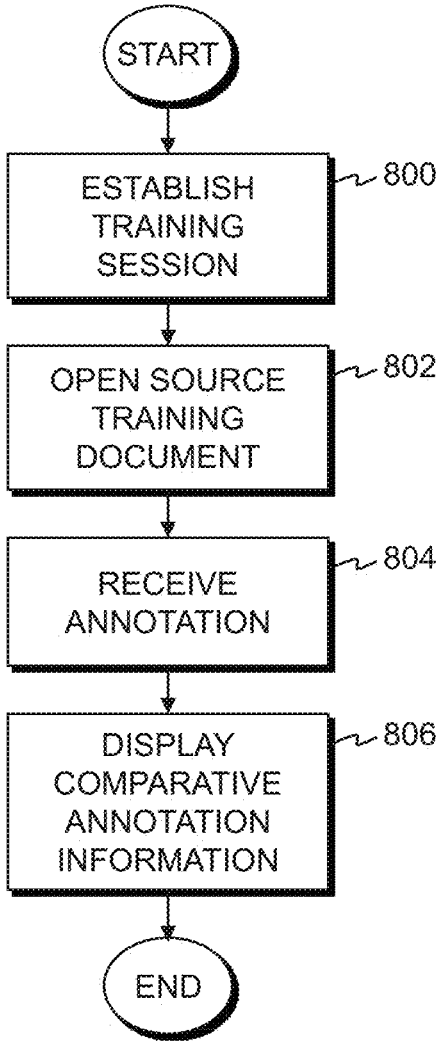
START
ESTABLISH TRAINING SESSION
800
OPEN SOURCE TRAINING DOCUMENT
802
RECEIVE ANNOTATION
804
DISPLAY COMPARATIVE ANNOTATION INFORMATION
806
END

FIG. 8

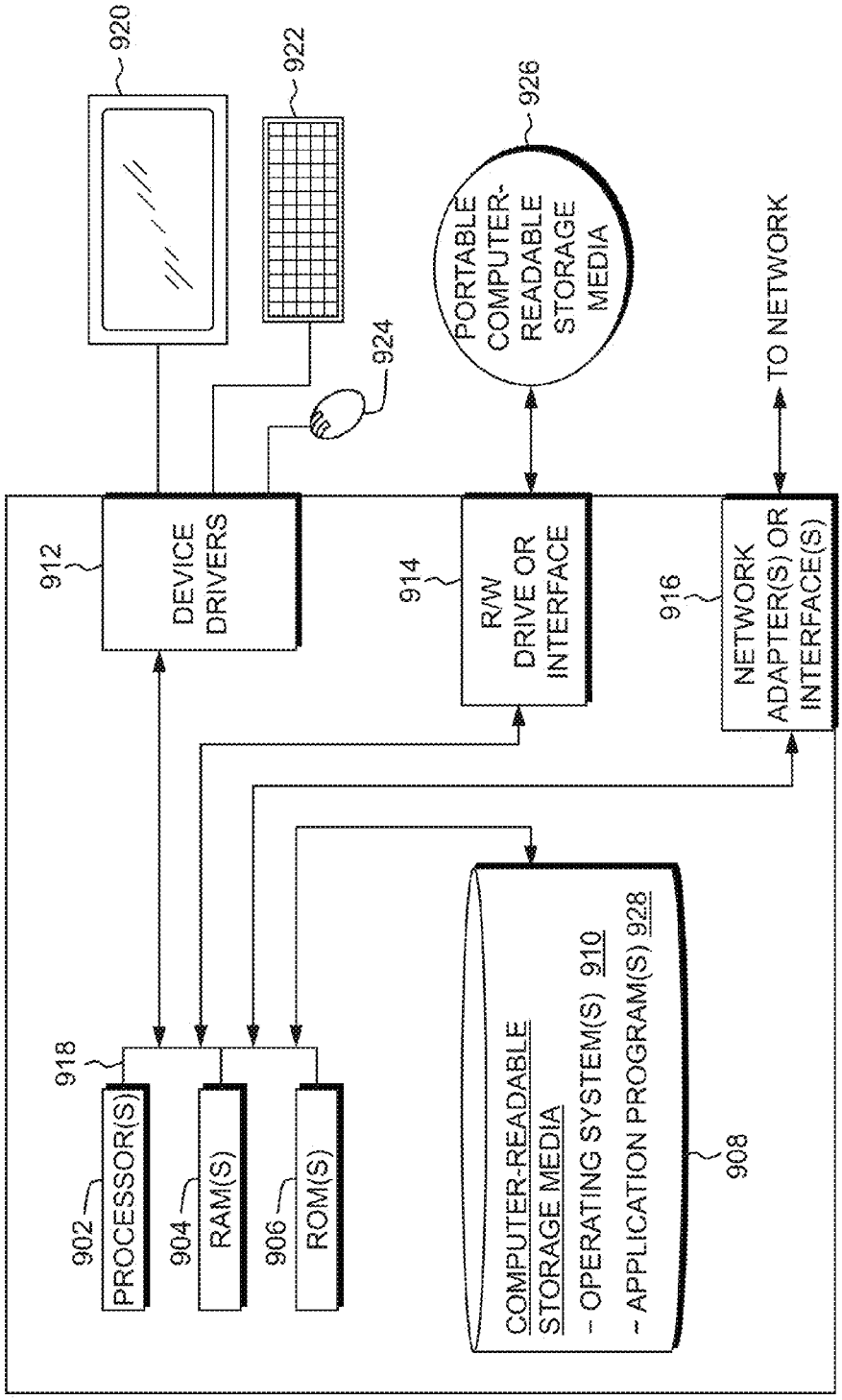
920
922
926
PORTABLE COMPUTER-READABLE STORAGE MEDIA
TO NETWORK
924
912
DEVICE DRIVERS
914
R/W DRIVE OR INTERFACE
916
NETWORK ADAPTER(S) OR INTERFACE(S)
918
902
PROCESSOR(S)
904
RAM(S)
906
ROM(S)
COMPUTER-READABLE STORAGE MEDIA
- OPERATING SYSTEM(S) 910
- APPLICATION PROGRAM(S) 928
908

FIG. 9

COLLABORATIVE CREATION OF ANNOTATION TRAINING DATA

BACKGROUND

[0001] The present invention relates generally to the field of data processing and the presentation processing of documents, and more particularly to a graphical user interface that supports synchronous collaborative work between multiple users.

SUMMARY

[0002] Embodiments of the present invention disclose a method, computer program product, and system for collaborative annotation of a document. A graphical user interface (GUI) is generated by a host computer that displays a document to annotate. The GUI is transmitted by the host computer to a plurality of client computers. A plurality of real time communication modes are established by the host computer between the client computers, each communication mode including communication channels between all the client computers. The host computer receives from the plurality of client computers a plurality of annotations entered into the GUIs at the client computers, each annotation identifying a span of words in the document to annotate and including an associated annotation type. The host computer updates the GUI to include for display the received plurality of annotations and inter-rater agreement statistics indicating the level of agreement between annotations received from each client computer and annotations received from the other client computers. The updated GUI is then transmitted by the host computer to the plurality of client computers.

[0003] In another aspect of the invention, conflicts between the received annotations are identified by the host computer. A conflict is one or more of an annotation with a span that partially overlaps the span of another annotation, an annotation with a span that partially or wholly overlaps the span of another annotation and the associated type of one of the annotations does not match the associated type of the other annotation, and a span of words associated with fewer annotations than the number of the plurality of client computers. Updating, by the host computer, the GUI further includes including for display the identified conflicts between the received annotations.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0004] FIG. **1** is a functional block diagram of a collaborative document annotation system, in accordance with an embodiment of the present invention.

[0005] FIG. **2** is a functional block diagram of the collaborative annotation program of FIG. **1**, in accordance with an embodiment of the present invention.

[0006] FIG. **3** is a functional block diagram of the collaborative session manager module of FIG. **2**, in accordance with an embodiment of the present invention.

[0007] FIG. **4** is an illustration of the record layout of the annotation datastore of FIG. **2**, in accordance with an embodiment of the present invention.

[0008] FIGS. **5**A and **5**B illustrate a graphical user interface for collaborative annotation, in accordance with an embodiment of the present invention.

[0009] FIG. **6** is a flowchart depicting operational steps of the collaborative session manager module of FIG. **2**, in accordance with an embodiment of the present invention.

[0010] FIGS. **7**A and **7**B illustrate a graphical user interface for annotator training, in accordance with an embodiment of the present invention.

[0011] FIG. **8** is a flowchart depicting operational steps of the annotation training module of FIG. **2**, in accordance with an embodiment of the present invention.

[0012] FIG. **9** is a functional block diagram of components of a client computing device and/or a server device of the collaborative document annotation system of FIG. **1**, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0013] Correctly annotated documents may form the basis for training data for natural language processing (NLP) based automated annotation systems. Correctly annotated documents may also be used as training tools to train human annotators. Various embodiments of the invention are directed to collaboratively producing correctly annotated documents in real time, or synchronously. Annotators may collaboratively annotate a document via, for example, a graphical user interface (GUIs) at each annotator's computing device. The synchronous collaborative annotation sessions are managed by a session manager application on a network server. The session manager receives annotations from each annotator and can display all received annotations on each annotator's GUI. As annotations are received, the session manager may compute various inter-rater agreement scores, for example, Kappa scores, indicating, for example, the level of agreement among all annotators for a given annotation, or the level of agreement of a specific annotator to all other annotators for one or more annotations.

[0014] To assist the annotators, in arriving at a consensus for an annotation, or, for example, arriving at an inter-rater agreement score above a threshold value, the GUIs include one or more real time communication channels between the annotators managed by the session manager. The communication channels may include, for example, a real time group chat session, a real time video conference, a real time group audio channel, etc. The real time communication occurring over the communication channels may be stored, and include timing marks that associate portions of the communications to an annotation being discussed. The annotators may iteratively annotate a phrase until a desired level of agreement is reached. A history of how each annotation progressed to a correct annotation may be stored to assist in identifying persistent annotation issues, in calculating inter-rater agreement scores, and in training human annotators to correctly annotate documents.

[0015] An annotation coordinator may act as the final arbiter in resolving conflicting annotations and determining the "correct" annotation. In certain embodiments, NLP based tools may assist the annotation coordinator in determining a correct annotation by, for example, analyzing a corpus of previously annotated documents and providing ranked recommendations for resolving specific annotation conflicts.

[0016] In various embodiments, a guideline outline may be automatically generated that includes, for example, a summarization by type of each annotation in the document. A summary by type may include, for example, each correct annotation and the associated incorrect annotations, and links to any associated real time discussions that may have

occurred over the multimodal communication interfaces. The guideline outline may form the basis of a training guideline document for the specific type of document being annotated. For example, based on an automatically generated guideline outline, a training guideline document may include correct examples for each type of annotation expected to be encountered in a source document. The training guideline document may also include examples of frequently occurring incorrect annotations associated with each annotation type, and links to relevant real time discussion that may have occurred during creation of the correctly annotated document.

[0017] In certain embodiments of the invention, human annotators may be trained to annotate documents based on a corpus of correctly annotated documents. The session manager, operating in a single user training mode, may manage, for example, a GUI at an annotator's computing device that displays the unannotated text from a previously correctly annotated document. As the annotator annotates the text, various statistics, for example, inter-rater agreement scores, and other information may be displayed to the annotator to assist in the training.

[0018] In embodiments of the invention, an annotation may be a comment associated with text, image, or other objects in a document, collectively referred to herein as text. The comments may be limited to certain recommended or allowed comments. Annotation involves selecting one or more spans of words or characters, or phrases, in a document, and entering a comment to associate with the phrase or phrases. A phrase may be a single word, multiple words, multiple characters, a sentence, or multiple sentences. A phrase may also include images and other objects in a document. In an exemplary embodiment described in more detail below, medical case notes are annotated with a specific set of "entity types," for example, "Chief Complaint," "Vital Sign," etc. Two or more phrases may be linked by a "relation" annotation, for example, "Cause Of," "Location Of," etc. The span of one annotated phrase may wholly or partially overlap the span of another annotated phrase.

[0019] FIG. **1** is a functional block diagram of collaborative document annotation system **100**, in accordance with an embodiment of the present invention. Collaborative document annotation system **100** includes network server **110** and client computing devices **120**, all interconnected over a network **130**.

[0020] Network **130** can be, for example, a local area network (LAN), a wide area network (WAN) such as the Internet, or a combination of the two, and can include wired, wireless, or fiber optic connections. In general, network **130** can be any combination of connections and protocols that will support communications between server **110** and client devices **120**, in accordance with embodiments of the invention.

[0021] In various embodiments of the invention, a client computing device **120** may be, for example, a laptop computer, tablet computer, netbook computer, personal computer (PC), a desktop computer, a personal digital assistant (PDA), or a smart phone. In general, a client computing device **120** may be any programmable electronic device capable of communicating with server **110** via network **130**, and of supporting functionality as required by one or more embodiments of the invention. A client computing device **120** may include internal and external hardware components as depicted and described in further detail below with reference to FIG. **9**. As described in more detail below, each client computing device **120** includes a graphical user interface **122**.

[0022] Server computer **110** may be a laptop computer, netbook computer, personal computer (PC), a desktop computer, or any programmable electronic device capable of hosting collaborative annotation program **112**, described below, and communicating with client devices **120** via network **130**, in accordance with embodiments of the invention. Server computer **110** may include internal and external hardware components, as depicted and described in further detail below with reference to FIG. **9**.

[0023] In an embodiment of the invention, server computer **110** includes collaborative annotation program **112**, source documents **114**, training documents **116**, and central annotation store **118**.

[0024] Source documents **114** represents a store of documents that may be annotated. Source documents **114** may reside, for example, on computer readable storage media **908** (FIG. **9**). These documents may include, for example, word processing documents, such as documents generated by Microsoft Word®, OpenOffice® Writer®, or other proprietary or open source word processing systems. The documents may also include records, or fields within records, created by special purpose application systems. For example, in an exemplary embodiment, a document may be one or more medical case note entries in an electronic health record (EHR) or electronic medical record (EMR) created by medical professional during a patient examination using a proprietary or open source EHR/EMR system. One of skill in the art will recognize that the principles of the invention apply to annotating any type of source document, such as a video, a picture, a file written in HTML, or other formats such as text, XML, or PDF.

[0025] Training documents **116** represents a store of correctly annotated source documents **114**. Training documents **116** may be used, for example, to train NLP based automated annotation systems, and to assist in training human annotators. Central annotation store **118** represents a store of all annotations received by collaborative annotation program **112** from annotators via client computing devices **120**. These annotations may be used, for example, to assist annotators, to train NLP based automated annotation systems, and to assist in training human annotators.

[0026] Collaborative annotation program **112** operates generally to host a collaborative annotation session between multiple client computing devices **120** to enable multiple annotators to collaboratively annotate a source document **114** in real time. As described in more detail below, collaborative annotation program **112** may receive an initial request, for example, from a client computing device **120**, to open a source document **114** in source documents **114** for annotation. Collaborative annotation program **112** initiates a collaborative annotation session by, for example, establishing the necessary datastores in the memory of server **110** to manage the collaborative annotation session, and transmitting a GUI **122** to the initiating client computing device **120** to allow annotation of the document. As additional client computing devices **120** join the collaborative annotation session, they also receive a GUI **122**. In an exemplary embodiment, collaborative annotation program **112** establishes multimodal communications between client computing devices **120** via the GUIs **122** to allow annotators to communicate and collaborate during the collaborative annotation session. The

multimodal communications may include, for example, a real time group chat session, a real time video conference, etc.

[0027] FIG. **2** is a functional block diagram of collaborative annotation program **112**, in accordance with an embodiment of the invention. Collaborative annotation program **112** may include collaborative session manager **200**, annotation training module **202**, and multimodal application manager **204**.

[0028] Collaborative session manager **200** operates generally to manage the GUIs **122** on client computing devices **120**, to track and store annotations of a document **114** received via the GUIs **122**, and, when annotation of a document is complete, to write out the annotated document as a correctly annotated training document **116**. In an exemplary embodiment, all annotations received by collaborative session manager **200** for all annotated documents are stored in central annotation store **118**.

[0029] FIG. **3** is a functional block diagram of collaborative session manager **200**, in accordance with an embodiment of the invention. Collaborative session manager **200** may include GUI manager **300**, annotator information datastore **302**, annotation tracking module **304**, and working document datastore **312**. Annotation tracking module further includes annotation datastore **306**, annotation conflict module **308**, and inter-rater statistics module **310**.

[0030] In an exemplary embodiment, GUI manager **300** operates to manage the GUIs **122** on computing devices **120**. When a collaborative annotation session is initially invoked, for example, by entering a universal resource locator (URL) into a web browser on a client computing device **120**, server **110** receives the request, for example, over network **130**, and directs it to collaborative annotation program **112**. Within collaborative annotation program **112**, the request is passed to GUI manager **300** of collaborative session manager **200** to initialize the session.

[0031] GUI manager **300** may send an initial login web page to a GUI **122**, for example, a web browser, on the requesting client computing device **120** to request, for example, an annotator ID and a source document to annotate. When the requestor enters and transmits an annotator ID and source document name back to GUI manager **300**, the GUI manager may initialize and/or populate annotator information datastore **302**, described just below, with information identifying the collaborative annotation session requestor, and may identify the requestor as the collaborative annotation session coordinator. As additional annotators join the collaborative annotation session, information for each annotator is entered into annotator information datastore **302**.

[0032] Annotator information datastore **302** represents a datastore, for example allocated storage on computer readable storage media **908**, to record information associated with each annotator who joins a collaborative annotation session. This information may include, for example, an annotator ID for each annotator, the network address of the client computing device **120** associated with an annotator ID, a color or other distinguishing characteristics associated with annotations received from an annotator, an indicator indicating whether an annotator is acting as the collaborative annotation session coordinator, etc.

[0033] GUI manager **300** may then retrieve the document to annotate from source documents **114**, and load the document into working document datastore **312**. Working document datastore **312** represents a datastore, for example allocated storage on computer readable storage media **908**, that is used as working storage for a source document **114** while the document is being annotated. In an embodiment, metadata is added to the retrieved document that associates a number with each "word" in the document. For example, a word may be defined as one or more contiguous alphanumeric characters delimited by one or more spaces (or other characters, such as a dash), and each word in the document, beginning with the first, may be consecutively numbered. A word may also include other objects in the document, such as images. In other embodiments, each character, or other groupings of characters, such as syllables, may be numbered. As described in more detail below, this metadata provides a mechanism to identify the span of an annotation.

[0034] GUI manager **300** may then transmit to the requesting client computing device **120** a collaborative annotation web page, such as collaborative annotation web page **500** (FIG. **5**), described in more detail below. In various embodiments, the collaborative annotation web page provides a way for annotators to enter and submit annotations of the document to collaborative session manager **200**, and to display annotations submitted by each annotator to all annotators. For example, the collaborative annotation web page may include a version of the source document from working document store **312**, including the word and/or character numbering metadata, embedded in the web page, and Java scripts that facilitate user annotation of the embedded document and transmittal of the annotations to GUI manager **300**.

[0035] The collaborative annotation web page may also provide a platform to embed one or more multimodal communication interfaces, such as multimodal communication interfaces **508**, described in more detail below, to allow communications between the computing devices **120** that are collaboratively annotating the source document **114**. In an embodiment, when two or more client computing devices **120** have joined a collaborative annotation session hosted by collaborative session manager **200**, multimodal application manager **204** (FIG. **2**) may, at the request of the collaborative session manager, establish one or more multimodal communication sessions between the client computing devices. For example, multimodal application manager **204** may establish one or more server based communications interfaces, such as an instant messaging application, a video chat application, a voice application, etc. These communication applications may include any suitable proprietary or open source server based communications interfaces, in accordance with an embodiment of the invention. In an embodiment, multimodal application manager **204** may establish one or more server based communications interfaces between all annotators based on the network addresses associated with the annotators stored in annotator information datastore **302**. These interfaces may be embedded in the collaborative annotation web pages managed by GUI manager **300**.

[0036] In certain embodiments, the real time communications occurring over the multimodal communication interfaces are stored in a datastore. The stored communications may include, for example, timing marks, entered, for example, by the collaborative session coordinator, to associate portions of the communications with the annotations that are being discussed. Links to these timing marks may be included in the metadata written to the working document in working document datastore **312** to link annotations to real time discussions that may have occurred over one or more of the multimodal communication interfaces.

[0037] Returning to FIG. **3**, after GUI manager **300** has transmitted collaborative annotation web pages to all client

computing devices **120** that have joined the collaborative annotation session, and multimodal communication interfaces have been established by multimodal application manager **204** between all the client computing devices, annotators may begin to annotate the selected source document **114** embedded in the collaborative annotation web pages. As each annotation is received by GUI manager **300** via, for example, the GUI interfaces **122**, the annotations are recorded by annotation tracking module **304** in annotation datastore **306**.

[0038] In certain embodiments, client computing device interaction with server **110** is conducted through a collaborative annotation client application that resides on each client computing device **120**. In these embodiments, for example, GUI manager **300** of collaborative session manager **200** may perform certain centralized functions, and the resident client application may provide the annotator interface. For example, each resident client application may request and receive a copy of the desired source document **114** and prepare the source document for annotation, by, for example, embedding metadata that identifies the position of each character in the source document. As each annotator annotates their copy of the source document **114**, via their resident client application, the annotations are transmitted to GUI manager **300**. GUI manager **300** may record all received annotations in annotation datastore **306** and central annotation datastore **118**, and transmit each annotation received to all executing resident client applications on client computing devices **120**, which then may update their local copies of the source document **114**. GUI manager **300** may also identify annotation conflicts and calculate inter-rater agreement statistics, which may then be transmitted to the resident client applications for display to the annotators.

[0039] FIG. **4** illustrates a field layout for entries in annotation datastore **306**, in accordance with an embodiment of the invention. The fields may include annotator ID (ANNR ID), an annotation timestamp (TIME), the annotation span(s) (SPAN(S)), and the type of the annotation (TYPE). Those of skill in the art will recognize that annotation datastore **306** may include many additional and/or different fields, depending on the design of various implementations. In this example, annotator ID may be the annotator login ID from annotator information datastore **302**. The annotation timestamp represents any internal representation of a time or date/time, in accordance with an embodiment of the invention. Annotation span(s) may be defined as, for example, the starting word or character of the annotation and the ending word or character of the annotation, as illustrated, or any other suitable span format. An annotation may include, or require, more than one annotation span. For example, as illustrated, the second annotation, received from annotator ID "Robert," has the type "LocationOf," which is a relation type annotation. In the exemplary embodiment, relation type annotations link two or more annotation spans. For example, a LocationOf relation type annotation may link an anatomic site to a finding, such as "right lung," an anatomic site, located in the source document beginning at word location **123** and extending to word **125**, is the location of "pneumonia," a finding, located in the source document beginning and ending at word location **133**.

[0040] Returning to FIG. **3**, as annotations are received from client computing devices **120** that have joined the collaborative annotation session, GUI manager **300** may update the collaborative annotation web page to include all received annotations, and transmit the updated page to all client computing devices **120**. As described in more detail below, annotations embedded in the web page may, for example, include metadata identifying the annotator, and may, for example, include color formatting information so that annotations from each annotator are displayed in a characteristic color. Embedded Java scripts may, for example, cause the display of information related to an annotation, such as how all annotators annotated a particular span, when the cursor is positioned over a span of annotated text in an annotated source document **114**.

[0041] When annotations are received from multiple annotators, annotation conflicts may be identified by annotation conflict module **308**. Annotation conflicts result when annotations from all annotators do not match. For example, the span of one annotation may partially, but not exactly, overlap the span of another annotation, or the annotation type of overlapping annotations may differ. Another type of conflict is where an annotation has not been identified by all annotators.

[0042] For example, collaborative session manager **200** receives a request from client computing device **120**A, to annotate the phrase "loud sneezing" with the type "ChiefComplaint" in a source document **114** that is being collaboratively annotated. Annotation tracking module **304** then adds a record to annotation datastore **306** recording the location, span, and type of the annotation. A second annotation request is received and recorded from client computing device **120**B to annotate the phrase "sneezing" with the type "ChiefComplaint." These two annotations conflict because, although the annotation type matches, the span is different.

[0043] If all annotators agree, then annotation datastore **306** will include groupings of annotations having identical spans and types, and each grouping will include one annotation per annotator. Conflicts between annotations exist when an annotation has a span that partially overlaps the span of another annotation, an annotation has a span that partially or wholly overlaps the span of another annotation and the associated type of one of the annotations does not match the associated type of the other annotation, or a span of words is associated with fewer annotations than the number of the client computers.

[0044] Annotation conflict module **308** may identify annotation conflicts by, for example, sorting the entries in annotation datastore **306** by span. Conflicting annotations may be identified in the sorted entries as entries that only partially overlap adjacent sorted entries, adjacent sorted entries that exactly overlap but have different types, and groupings of matching entries (or single-entry groups) that do not include entries from all annotators who were or are members of the collaborative annotation session. Similarly, for relation type annotations, conflicts may be identified for each span and associated type of the relation, and for the relation type of the annotation. In an embodiment, GUI manager **300** may embed metadata in the collaborative annotation web page that may identify conflicting annotations with a particular display characteristic, such as color, font, formatting, etc.

[0045] In an exemplary embodiment, inter-rater statistics module **310** may analyze the annotation entries in annotation datastore **306** to produce statistical measures indicating a level of agreement among annotators with respect to their annotations. For example, statistics may be produced showing the level of overall agreement between all annotators for all annotations in a source document, the level of agreement of each annotator to all other annotators, the level of agree-

ment between each annotator and the correct annotations in a source documents, etc. In certain embodiments, all annotations for all collaboratively annotated documents are recorded in central annotation store **118**. For these embodiments, inter-rater statistics module **310** may produce statistics that take into account these historical entries. For example, a certain phrase that is annotated in the current source document **114** may have appeared in, and been annotated in, other source documents. Inter-rater statistics module **310** may include these historical annotations in certain inter-rater agreement calculations. Such statistics may be displayed on the collaborative annotation web pages to assist annotators in better arriving at consensus annotations.

[0046] In various embodiments, inter-rater statistics module **310** may use any suitable statistical calculation to produce inter-rater agreement scores, as may be known to those skilled in the art. Typically, inter-rater agreement scores are calculated by determining the degree of agreement in classification over that which would be expected by chance. For example, the level of agreement between all annotators may be calculated using Fleiss' kappa, which is a statistical measure for assessing the reliability of agreement between a fixed number of raters when assigning categorical ratings to a number of items or classifying items. The level of agreement between an annotator and the correct annotations may be calculated using, for example, Cohen's kappa or Scott's pi statistic. Those of skill in the art will recognize that other statistical measures may be used to determine inter-rater agreement. More sophisticated approaches may also be used, such as using weighted kappa measures to indicate that certain disagreements between types may be given more weight.

[0047] Returning to FIG. **2**, after all annotations have been agreed upon, for example, by having the annotator designated as the collaborative annotation session coordinator indicate all correct annotations, collaborative session manager **200** may produce a correctly annotated version of the source document **114** and write the document to training documents **116**. A correctly annotated version may be produced, for example, by extracting a correctly annotated version from working document datastore **312**, and writing the document to training documents **116** in the desired document format or formats. One format of the training document **116** may include, for example, metadata that includes the annotation history of the document that may be used for annotator training purposes.

[0048] Returning to FIG. **1**, a client computing device **120** includes a GUI **122**. In an exemplary embodiment, a GUI **122** is a collaborative annotation web page transmitted from GUI manager **300** of collaborative session manager **200**, and displayed in a web browser executing on the client computing device **120** that allows an annotator to interact with collaborative annotation program **112** on server **110**.

[0049] FIGS. **5**A and **5**B illustrate a GUI **122**, in accordance with an embodiment of the invention. As mentioned above, in an exemplary embodiment, GUI **122** is a collaborative annotation web page **500** displayed in a web browser executing on a client computing device **120**. Collaborative annotation web page **500** includes a document pane **502**, an annotations pane **504**, an annotator listing pane **506**, a multimodal communications pane **508**, and an inter-rater agreement statistics pane **510**. HTML code and embedded Java scripts may control how information is presented on the web page, and control interactions of the annotator with this information.

[0050] Document pane **502** contains the source document **114** that is being annotated. In an exemplary embodiment, document pane **502** includes all annotations from all annotators. For example, when an annotator annotates a phrase within the document pane **502** of the GUI **122** displayed on the client computing device **120** of the annotator, information defining the annotation, such as annotator ID, annotation location and span, annotation type, etc., is transmitted to collaboration session manager **200**. The annotation information may be passed to annotation tracking module **304**, where it may be stored in annotation datastore **306**, any conflicts with other annotations may be identified by annotation conflict module **308**, and inter-rater statistics may be updated by inter-rater statistics module **310**. Annotation information may then be passed to GUI manager **300**, which may incorporate the just-received annotation, as well as any changed annotation conflict and inter-rater statistics information, into working document datastore **312**. GUI manager **300** may then generate an updated collaborative annotation web page **500** and transmit the new collaborative annotation web page to all GUIs **122** so that the just-received annotation will be displayed on all GUIs **122**. In various embodiments, GUI manager **300** may create "personalized" collaborative annotation web pages **500**, for example, with respect to inter-rater statistics, and transmit a personalized collaborative annotation web page to each GUI **122** that is specific to the annotator using the client computing device **120**.

[0051] FIG. **5**A illustrates an embodiment of how a phrase may be annotated. As shown, the phrase "Maecenas egestas enim," located within the text displayed in document pane **502**, has been selected, for example, by left-clicking a mouse or other pointing device and highlighting the desired span of text by dragging a "select" mouse pointer over the desired phrase. In FIG. **5**A, the selected text is indicated as shaded. The annotator may then right-click the mouse to display a context drop-down menu that displays selectable "type" entries. When the annotator selects a type, this information may then be transmitted to collaborative session manager **200**.

[0052] FIG. **5**B illustrates an embodiment of how annotation information from all annotators may be displayed. As shown, the phrase "loud sneezing," located within the text displayed in document pane **502** is bolded and underlined, indicating that the phrase has been annotated by one or more annotators. Locating the mouse cursor over the phrase results in a display in annotations pane **504** of information that may include how annotators have annotated the phrase.

[0053] Annotator listing pane **506** may display a listing of all annotators that contributed annotations to the current annotated source document **114**, including an indication of whether the annotator is available in one or more collaborative session real time multimodal communication interfaces. Multimodal communications pane **508** may include one or more real time communication interfaces, established and controlled by multimodal application manager **204**, as described above. For example, in the embodiments illustrated in FIGS. **5**A and **5**B, real time communication interfaces that have been established for the collaborative annotation session includes a streaming video interface, a streaming audio interface, and an instant messaging, or chat, interface. The multimodal communications pane **508** associated with the collaborative session coordinator may also include the ability to enter timing marks to associate portions of a real time discussion to an annotation being discussed.

[0054] Inter-rater agreement statistics pane **510** includes statistics generated by inter-rater statistics module **310**. In the illustrated embodiment inter-rater agreement statistics pane **510** includes the level of agreement of the annotator using this collaborative annotation web page **500** to all other annotators, and the level of agreement between this annotator and the correct annotations in the annotated source document **114**.

[0055] FIG. **6** is a flowchart depicting operational steps of collaborative annotation program **112** of FIG. **1**, in accordance with an embodiment of the invention. When collaborative annotation program **112** receives a request to establish a collaborative annotation session, for example, by receiving a request as the result of an annotator entering the URL of collaborative annotation program **112** on network server **110** into a web browser residing on a client computing device **120**, the collaborative annotation program establishes a collaborative annotation session (step **600**). In establishing the collaborative annotation session, collaborative annotation program **112** may respond to the request by transmitting a web page to the browser on the requesting client computing device **120** that requests the name of the document that will be annotated.

[0056] When the name of the document that will be annotated is received by collaborative annotation program **112**, the document may be retrieved from source documents **114** and loaded into working document store **312** (step **602**). Metadata may be embedded in the document to, for example, number each word. The formatted document, included embedded metadata, may be embedded in a collaborative annotation web page, along with, for example, Java scripts that enable an annotator to annotate the document, and transmitted to the requesting client computing device **120** for display in, for example, a web browser. Additional display elements are also embedded in the collaborative annotation web page, such as multimodal communication interfaces allowing for real time communication and interaction among all annotators active in the collaborative annotation session, and statistics, indicating agreement among the annotators with respect to their annotations.

[0057] When all annotators have joined the collaborative annotation session, GUI manager **300** may receive and track annotations received from client computing devices **120**, via, for example, GUIs **122** (step **604**). Annotation tracking module **304** tracks the received annotations in annotation datastore **306**, and updates the source document in working document datastore **312**. GUI manager **300** may then update the collaborative annotation web page **500** with the changes to working document datastore **312** and transmit a new version of the web page to all client computing devices **120** so that all each annotator may display annotations from all other annotators.

[0058] Conflicts between annotations are identified by annotation conflict module **308** (step **606**), for example, as described above. The annotation conflict information may be embedded in the source document metadata in working document datastore **312** so that it may be displayed to all annotators via each GUI **122** (step **608**). Discussions between annotators may occur via one or more of the multi-modal communication interfaces **508** embedded in the collaborative annotation web page **500** to resolve annotation conflicts, and updated annotations may be received by collaborative session manager **200** (steps **610**; step **612**, "N" branch). The real time communications occurring over the multi-modal communication interfaces **508** may be stored in a datastore. The collaborative annotation session coordinator may have the ability to add timing marks to the saved communications to associate portions of the real time discussion to annotations being discussed. Links to these timing marks may be included in the embedded metadata associated with the annotations.

[0059] In various embodiments, all annotations are recorded in central annotation store **118**. When, for example, the collaborative session coordinator has resolved all annotation conflicts by defining "correct" annotations (step **612**, "Y" branch), collaborative session manager **200** may write the correctly annotated source document **114** in working document datastore **312** to training documents **116** (step **614**). In certain embodiments, collaborative session manager **200** may also automatically create a guideline outline from the annotated document and metadata written to working document store **312** that includes, for example, a summarization by type of each annotation in the document. A summary by type may include, for example, each correct annotation and the associated incorrect annotations, and links to any associated real time discussions that may have occurred over the multimodal communication interfaces. The guideline outline may form the basis of a training guideline document for the specific type of document being annotated. For example, based on an automatically generated guideline outline, a training guideline document may include correct examples for each type of annotation expected to be encountered in a source document. The training guideline document may also include examples of frequently occurring incorrect annotations associated with each annotation type, and links to relevant real time discussion that may have occurred during creation of the correctly annotated document.

[0060] As mentioned above, in certain embodiments of the invention, human annotators may be trained to annotate documents based on a corpus of correctly annotated documents, for example, training documents **116**. Returning to FIG. **2**, collaborative annotation program **112**, operating in a single user training mode, may manage a GUI **122** at an annotator's client computing device **120**, via annotation training module **202**, that may display the unannotated text from a previously correctly annotated document from training documents **116**. As the annotator annotates the text, various statistics, for example, inter-rater agreement scores, and other information may be displayed to the annotator to assist in the training. In these embodiments, annotation training module **202** may make use of certain functionalities of the various modules of collaborative session manager **200**, described above.

[0061] FIGS. **7**A and **7**B illustrate a GUI **122**, in accordance with an embodiment of the invention that includes an annotator training capability. In an exemplary embodiment, GUI **122** is a annotation training web page **700** displayed in a web browser executing on a client computing device **120**. Annotation training web page **700** is similar in many aspects to collaborative annotation web page **500**, described above. Annotation training web page **700** includes a document pane **702**, an annotations pane **704**, and an inter-rater agreement statistics pane **710**. HTML code and embedded Java scripts may control how information is presented on the web page, and control interactions of the annotator with this information.

[0062] Document pane **700** contains the training document **116** that is being used to train the annotator. In one embodiment, the training document **116** includes metadata, or associated files, that may be used to produce an unannotated version of the training document, and that also includes anno-

tation history, for example, the information recorded to annotation datastore **306**, described above, when the document was originally annotated.

[0063] FIG. **7**A illustrates an embodiment of how a phrase may be annotated. As shown, the phrase "Maecenas egestas enim," located within the text displayed in document pane **702**, has been selected, for example, by left-clicking a mouse or other pointing device and highlighting the desired span of text by dragging a "select" mouse pointer over the desired phrase. In FIG. **7**A, the selected text is indicated as shaded. The annotator may then right-click the mouse to display a context drop-down menu that displays selectable "type" entries. When the annotator selects a type, this information may then be transmitted to collaborative session manager **200**, where it may be stored by annotation tracking module **304** in annotation datastore **306**.

[0064] FIG. **7**B illustrates an embodiment of how annotation information from previous annotators may be displayed. As shown, the phrase "loud sneezing," located within the text displayed in document pane **702**, is bolded and underlined, indicating that the phrase has been annotated by the annotator in training. In certain embodiments, the annotator in training may have access to how previous annotators annotated a phrase. For example, locating the mouse cursor over a phrase that has been annotated by the annotator in training may result in a display in annotations pane **704** of information that may include how previous annotators have annotated the phrase.

[0065] Inter-rater agreement statistics pane **710** includes statistics generated by inter-rater statistics module **310**. In the illustrated embodiment inter-rater agreement statistics pane **710** includes the level of agreement between the annotator in training and the original annotators of the source document, and the level of agreement between the annotator in training and the correct annotations in the training document **116**.

[0066] FIG. **8** is a flowchart depicting operational steps of annotation training module **202** of FIG. **2**, in accordance with an embodiment of the present invention. When collaborative annotation program **112** receives a request to establish an annotation training session, for example, by receiving the request as the result of an annotator entering the URL of collaborative annotation program **112** on network server **110** into a web browser residing on a client computing device **120**, collaborative annotation program **112** establishes an annotation training session (step **800**). In establishing the annotation training session, annotation training module **202** may respond to the request by transmitting a web page to the browser on the requesting client computing device **120** that requests the name of the training document that will be annotated.

[0067] When the name of the training document that will be annotated is received by annotation training module **202**, the document may be retrieved from training documents **116** and loaded into working document store **312** (step **802**). The training document **116** may include embedded metadata that, for example, numbers each word, and may include metadata and/or associated files that include the original source document annotations, including the "correct" annotations. GUI manager **300** may be called by annotation training module **202** to generate and transmit an annotation training web page to the requesting client computing device **120**. The training document, its metadata, and associated files may be embedded into, or transmitted with, the annotator training web page, such as a web page as illustrated in FIGS. **7**A and **7**B, to the requesting client computing device **120** for display in, for example, a web browser or other GUI **122**. The annotator training web page may also include Java scripts that enable an annotator to annotate the document and interact with annotation training module **202**.

[0068] GUI manager **300**, operating in single user mode, may receive and track annotations received from client computing device **120**, via, for example, a GUI **122** (step **804**). Annotation tracking module **304** tracks the received annotations in annotation datastore **306**, and updates the source document in working document datastore **312**. GUI manager **300** may then update the annotation training web page **700** with the changes to working document datastore **312** and transmit a new version of the web page to the client computing device **120**.

[0069] As the annotator in training submits annotations, conflicts between these annotations and the correct annotations may be identified by annotation conflict module **308**, for example, as described above (step **806**). Annotations submitted by the annotator in training that conflict with the correct annotation may, for example, be highlighted on the annotation training web page **700** as the annotation is submitted, upon request of the annotator in training, or periodically during the training session. Upon, for example, positioning the mouse cursor over the highlighted annotation, information concerning the conflict may be displayed to the annotator in training. In various embodiments, this information may include the correct annotation and/or annotations received when the training document was originally annotated. Inter-rater agreement statistics between the annotator in training and the correct annotations and/or annotations received when the training document was originally annotated may be displayed to the annotator in training to provide a qualitative assessment of the accuracy of the annotations of the annotator in training.

Alternative Embodiments

[0070] A particular embodiment of the invention has been described in detail above. However, those of skill in the art will recognize that the invention can be implemented in other embodiments without undue experimentation.

[0071] In one alternative embodiment, an annotation may take the form of a question and answer pair. For example, questions may be posed, such as "Who was the first American in space?" A variety of answers may be received, for example, "Shepard," "Alan Shepard," "Alan Bartlet Shepard," "John Glenn," and "Chuck Yeager." As above, a GUI may be presented to each participant that allows for, for example, entry of annotations, multi-modal communication between annotators, display of inter-annotator agreement statistics, and display of annotations from other annotators. A "correct" annotation may be identified, or, as the example answers may suggest, more than one annotation may be correct, or certain annotations may be flagged as more correct. All received annotations, and their degree or rank of "correctness," may be stored for later use to train human annotators, to produce training guidelines, and by NLP based systems as training data.

[0072] In another alternative embodiment, a question presented to an annotator may require a selection of multiple answers. For example, an annotator may be presented with the question "What finding is caused by Malaria?" and the answer choices "fever," "sweats," "chills," "nausea," and "vomiting." In various degrees stages of the disease, some or all of the findings may be present in a patient with Malaria. In

this example, any combination of the answer choices may be considered as correct, however, certain combinations may be considered as more correct, or have an associated higher rank. Again, as above, a GUI may be presented to each participant that allows for, for example, entry of annotations, multimodal communication between annotators, display of inter-annotator agreement statistics, and display of annotations from other annotators.

[0073] FIG. **9** depicts a block diagram of components of a client computing device **120** and/or a server **110** of FIG. **1**, in accordance with an embodiment of the present invention. It should be appreciated that FIG. **9** provides only an illustration of one implementation and does not imply any limitations with regard to the environments in which different embodiments may be implemented. Many modifications to the depicted environment may be made.

[0074] Client computing devices **120** and/or a server **110** may include one or more processors **902**, one or more computer-readable RAMs **904**, one or more computer-readable ROMs **906**, one or more computer readable storage media **908**, device drivers **912**, read/write drive or interface **914**, network adapter or interface **916**, all interconnected over a communications fabric **918**. Communications fabric **918** may be implemented with any architecture designed for passing data and/or control information between processors (such as microprocessors, communications and network processors, etc.), system memory, peripheral devices, and any other hardware components within a system.

[0075] One or more operating systems **910**, and one or more application programs **928**, for example, collaborative annotation program **112** and/or GUI **122**, are stored on one or more of the computer readable storage media **908** for execution by one or more of the processors **902** via one or more of the respective RAMs **904** (which typically include cache memory). In the illustrated embodiment, each of the computer readable storage media **908** may be a magnetic disk storage device of an internal hard drive, CD-ROM, DVD, memory stick, magnetic tape, magnetic disk, optical disk, a semiconductor storage device such as RAM, ROM, EPROM, flash memory or any other computer-readable tangible storage device that can store a computer program and digital information.

[0076] Client computing devices **120** and/or a server **110** may also include a R/W drive or interface **914** to read from and write to one or more portable computer readable storage media **926**. Application programs **928** on client computing devices **120** and/or a server **110** may be stored on one or more of the portable computer readable storage media **926**, read via the respective R/W drive or interface **914** and loaded into the respective computer readable storage media **908**.

[0077] Client computing devices **120** and/or a server **110** may also include a network adapter or interface **916**, such as a TCP/IP adapter card or wireless communication adapter (such as a 4G wireless communication adapter using OFDMA technology). Application programs **928** on computing devices **120** and/or a server **110** may be downloaded to the computing device from an external computer or external storage device via a network (for example, the Internet, a local area network or other wide area network or wireless network) and network adapter or interface **916**. From the network adapter or interface **916**, the programs may be loaded onto computer readable storage media **908**. The network may comprise copper wires, optical fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers.

[0078] Client computing devices **120** and/or a server **110** may also include a display screen **920**, a keyboard or keypad **922**, and a computer mouse or touchpad **924**. Device drivers **912** interface to display screen **920** for imaging, to keyboard or keypad **922**, to computer mouse or touchpad **924**, and/or to display screen **920** for pressure sensing of alphanumeric character entry and user selections. The device drivers **912**, R/W drive or interface **914** and network adapter or interface **916** may comprise hardware and software (stored on computer readable storage media **908** and/or ROM **906**).

[0079] The present invention may be a system, a method, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present invention.

[0080] The computer readable storage medium can be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

[0081] Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

[0082] Computer readable program instructions for carrying out operations of the present invention may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object ori-

ented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.

[0083] Aspects of the present invention are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

[0084] These computer readable program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

[0085] The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0086] The flowchart and block diagrams in the figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function (s). In some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

[0087] Based on the foregoing, a computer system, method, and computer program product have been disclosed in accordance with the present invention. However, numerous modifications and substitutions can be made without deviating from the scope of the present invention. Therefore, the present invention has been disclosed by way of example and not limitation.

[0088] The foregoing description of various embodiments of the present invention has been presented for purposes of illustration and description. It is not intended to be exhaustive nor to limit the invention to the precise form disclosed. Many modifications and variations are possible. Such modification and variations that may be apparent to a person skilled in the art of the invention are intended to be included within the scope of the invention as defined by the accompanying claims.

What is claimed is:

1. A method for collaborative annotation of a document, the method comprising:

generating, by a host computer, a graphical user interface (GUI) that displays a document to annotate;

transmitting, by the host computer to a plurality of client computers, the GUI;

establishing, by the host computer, a plurality of real time communication modes between the client computers, each communication mode including communication channels between all client computers;

receiving, by the host computer from the plurality of client computers, a plurality of annotations entered into the GUIs at the client computers, each annotation identifying a span of words in the document to annotate and including an associated annotation type;

updating, by the host computer, the GUI to include for display the received plurality of annotations and inter-rater agreement statistics indicating the level of agreement between annotations received from each client computer and annotations received from the other client computers; and

transmitting, by the host computer to the plurality of client computers, the updated GUI.

2. A method in accordance with claim **1**, further comprising:

identifying, by the host computer, conflicts between the received annotations, wherein a conflict is one or more of: an annotation with a span that partially overlaps the span of another annotation, an annotation with a span that partially or wholly overlaps the span of another annotation and the associated type of one of the annotations does not match the associated type of the other annotation, and a span of words associated with fewer annotations than the number of the plurality of client computers; and

wherein updating, by the host computer, the GUI further includes including for display the identified conflicts between the received annotations.

3. A method in accordance with claim **1**, further comprising:

receiving, by the host computer from one or more of the plurality of client computers, annotations identified as correct annotations; and

wherein the inter-rater agreement statistics further indicate the level of agreement between annotations received from each client computer and corresponding annotations identified as correct annotations.

4. A method in accordance with claim **3**, further comprising:

receiving, by the host computer from one of the plurality of client computers, an indication that the all correct annotations have been received; and

writing to a datastore the annotated document, including at least all the correct annotations.

5. A method in accordance with claim **4**, further comprising:

storing, by the host computer, all communications occurring over the plurality of real time communication modes between the client computers;

in response to receiving, by the host computer, a request to generate a timing mark, storing an association of an annotation and a timestamp of the real time communications;

writing to a datastore a guideline outline that includes one or more of: a summarization by type of each annotation in the annotated document; each correct annotation and the associated incorrect annotations; and links to any associated real time discussions that may have occurred over the multimodal communication interfaces; and

wherein writing to a datastore the annotated document further includes writing the associations of the annotations and timestamps of the real time communications.

6. A method in accordance with claim **1**, wherein the GUI is a web page that includes embedded scripts to receive annotations of the document to annotate from a user of a client computer and transmit the annotations to the host computer.

7. A computer program product for collaborative annotation of a document, the method comprising:

one or more computer-readable storage media and program instructions stored on the one or more computer-readable storage media, the program instructions comprising:

program instructions to generate, by a host computer, a graphical user interface (GUI) that displays a document to annotate;

program instructions to transmit, by the host computer to a plurality of client computers, the GUI;

program instructions to establish, by the host computer, a plurality of real time communication modes between the client computers, each communication mode including communication channels between all client computers;

program instructions to receive, by the host computer from the plurality of client computers, a plurality of annotations entered into the GUIs at the client computers, each annotation identifying a span of words in the document to annotate and including an associated annotation type;

program instructions to update, by the host computer, the GUI to include for display the received plurality of annotations and inter-rater agreement statistics indicating the level of agreement between annotations received from each client computer and annotations received from the other client computers; and

program instructions to transmit, by the host computer to the plurality of client computers, the updated GUI.

8. A computer program product in accordance with claim **7**, further comprising:

program instructions to identify, by the host computer, conflicts between the received annotations, wherein a conflict is one or more of: an annotation with a span that partially overlaps the span of another annotation, an annotation with a span that partially or wholly overlaps the span of another annotation and the associated type of one of the annotations does not match the associated type of the other annotation, and a span of words associated with fewer annotations than the number of the plurality of client computers; and

wherein the program instructions to update, by the host computer, the GUI further include program instructions to include for display the identified conflicts between the received annotations.

9. A computer program product in accordance with claim **7**, further comprising:

program instructions to receive, by the host computer from one or more of the plurality of client computers, annotations identified as correct annotations; and

wherein the inter-rater agreement statistics further indicate the level of agreement between annotations received from each client computer and corresponding annotations identified as correct annotations.

10. A computer program product in accordance with claim **9**, further comprising:

program instructions to receive, by the host computer from one of the plurality of client computers, an indication that the all correct annotations have been received; and

program instructions to write to a datastore the annotated document, including at least all the correct annotations.

11. A computer program product in accordance with claim **10**, further comprising:

program instructions to store, by the host computer, all communications occurring over the plurality of real time communication modes between the client computers;

program instructions, in response to receiving, by the host computer, a request to generate a timing mark, to store an association of an annotation and a timestamp of the real time communications;

program instructions to write to a datastore a guideline outline that includes one or more of: a summarization by type of each annotation in the annotated document; each correct annotation and the associated incorrect annotations; and links to any associated real time discussions that may have occurred over the multimodal communication interfaces; and

wherein the program instructions to write to the datastore the annotated document further includes program instructions to write the associations of the annotations and timestamps of the real time communications.

12. A computer program product in accordance with claim **7**, wherein the GUI is a web page that includes embedded scripts to receive annotations of the document to annotate from a user of a client computer and transmit the annotations to the host computer.

13. A computer system for collaborative annotation of a document, the method comprising:

one or more computer processors, one or more computer-readable storage media, and program instructions stored on one or more of the computer-readable storage media

for execution by at least one of the one or more processors, the program instructions comprising:

program instructions to generate, by a host computer, a graphical user interface (GUI) that displays a document to annotate;

program instructions to transmit, by the host computer to a plurality of client computers, the GUI;

program instructions to establish, by the host computer, a plurality of real time communication modes between the client computers, each communication mode including communication channels between all client computers;

program instructions to receive, by the host computer from the plurality of client computers, a plurality of annotations entered into the GUIs at the client computers, each annotation identifying a span of words in the document to annotate and including an associated annotation type;

program instructions to update, by the host computer, the GUI to include for display the received plurality of annotations and inter-rater agreement statistics indicating the level of agreement between annotations received from each client computer and annotations received from the other client computers; and

program instructions to transmit, by the host computer to the plurality of client computers, the updated GUI.

14. A computer system in accordance with claim **13**, further comprising:

program instructions to identify, by the host computer, conflicts between the received annotations, wherein a conflict is one or more of: an annotation with a span that partially overlaps the span of another annotation, an annotation with a span that partially or wholly overlaps the span of another annotation and the associated type of one of the annotations does not match the associated type of the other annotation, and a span of words associated with fewer annotations than the number of the plurality of client computers; and

wherein the program instructions to update, by the host computer, the GUI further include program instructions to include for display the identified conflicts between the received annotations.

15. A computer system in accordance with claim **13**, further comprising:

program instructions to receive, by the host computer from one or more of the plurality of client computers, annotations identified as correct annotations; and

wherein the inter-rater agreement statistics further indicate the level of agreement between annotations received from each client computer and corresponding annotations identified as correct annotations.

16. A computer system in accordance with claim **15**, further comprising:

program instructions to receive, by the host computer from one of the plurality of client computers, an indication that the all correct annotations have been received; and

program instructions to write to a datastore the annotated document, including at least all the correct annotations.

17. A computer system in accordance with claim **16**, further comprising:

program instructions to store, by the host computer, all communications occurring over the plurality of real time communication modes between the client computers;

program instructions, in response to receiving, by the host computer, a request to generate a timing mark, to store an association of an annotation and a timestamp of the real time communications;

program instructions to write to a datastore a guideline outline that includes one or more of: a summarization by type of each annotation in the annotated document; each correct annotation and the associated incorrect annotations; and links to any associated real time discussions that may have occurred over the multimodal communication interfaces; and

wherein the program instructions to write to the datastore the annotated document further includes program instructions to write the associations of the annotations and timestamps of the real time communications.

18. A computer system in accordance with claim **13**, wherein the GUI is a web page that includes embedded scripts to receive annotations of the document to annotate from a user of a client computer and transmit the annotations to the host computer.

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