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System and method for using an artificial intelligence (AI) model to route data

Abstract

Systems and methods for routing data using an artificial intelligence (AI) model are disclosed. The method includes receiving a data request associated with one or more data gaps, determining, by an AI model, a plurality of ranking values for a plurality of candidate data sources respectively based on one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; and routing, over a network, the data request to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values.

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Background/Summary

TECHNICAL FIELD

(1) The present disclosure relates generally to the field of predictive analytics, data processing, and data management. In particular, the present disclosure relates to using an artificial intelligence (AI) model to route data to data sources.

BACKGROUND

(2) Determining the most appropriate data sources for satisfying a data request is a costly and timely task that requires manual collection and storage of data across multiple constraints, such as cost, timeliness, and regulatory compliance.

(3) Rosters of data may include an extraordinarily large number of entities (e.g., organization such as, e.g., healthcare providers or other institutions), and each entity in the roster may have different data gaps that are required to be filled. A data request may be filed to fill the data gaps, but data sources may be costly, and not all data sources provide all necessary data for the roster.

Determining a single data source that provides the data necessary to fill the data gaps for every entity is often difficult, and determining optimal data sources for each individual entity is often time-consuming, resulting in frequently sub-optimal data sources being selected based on convenience that may result in high costs.

SUMMARY

(4) The present disclosure solves the technical challenges typically encountered during the use of a conventional method, such as those discussed above and elsewhere in the present disclosure. Specifically, the present disclosure solves the technical challenges by determining a ranking value

for one or more candidate data sources for a data request using an AI model, and providing an output list of the candidate sources sorted by the determined ranking values. The ranking values may reflect which of the plurality of data sources are best suited to provide requested data for each entry in a data set and the output list reports a summary of which data sources can minimally best provide needed data to the user to cover all entries in the data request. This allows for avoiding duplicating data requests, processing, and storage cost where data is available through multiple data sources.

(5) In some aspects, the techniques described herein relate to a computer-implemented method comprising: receiving, by one or more processors and from a user device, a user input including a data request associated with one or more data gaps, wherein the data request includes a data object including one or more entities and one or more attributes associated with each of the one or more entities; receiving, by the one or more processors, an input list including a plurality of candidate data sources for the data request; determining, by the one or more processors and an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; sorting, by the one or more processors and the AI model, the plurality of candidate data sources by the plurality of ranking values; in response to receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources; in response to receiving, by one or more processors and from the user device, a response to the output list: routing, by the one or more processors and over a network, the data request to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking, by the one or more processors, routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value.

(6) In some aspects, the techniques described herein relate to a system comprising: memory configured to store instructions; and one or more processors configured to execute the instructions to perform operations comprising: receiving, from a user device, a user input including a data request associated with one or more data gaps, wherein the data request includes a data object including one or more entities and one or more attributes associated with each of the one or more entities; receiving an input list including a plurality of candidate data sources for the data request; determining, by an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; sorting, by the AI model, the plurality of candidate data sources by the plurality of ranking values; in response to receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources; in response to receiving, from the user device, a response to the output list: routing the data request over a network to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value.

(7) In some aspects, the techniques described herein relate to a non-transitory computer-readable medium storing instructions that, when executed by one or more processors, cause the one or more processors to perform operations comprising: receiving, from a user device, a user input including a data request associated with one or more data gaps, wherein the data request includes a data object including one or more entities and one or more attributes associated with each of the one or more entities; receiving an input list including a plurality of candidate data sources for the data request;

determining, by an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; sorting, by the AI model, the plurality of candidate data sources by the plurality of ranking values; in response to receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources; in response to receiving, from the user device, a response to the output list: routing the data request over a network to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value.

(8) It is to be understood that both the foregoing general description and the following detailed description are example and explanatory only and are not restrictive of the detailed embodiments, as claimed.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate various example embodiments and, together with the description, serve to explain the principles of the disclosed embodiments.

(2) FIG. 1 is a diagram of an example environment for identifying data sources best suited for filling documentation gaps associated with a data request.

(3) FIG. 2 is a flowchart of an example process for identifying data sources best suited for filling data gaps associated with a data request.

(4) FIG. 3 is a flowchart of an example process for using an AI model to rank data sources best suited for filling data gaps associated with a data request.

(5) FIG. 4A is an example of a data object associated with a data request.

(6) FIG. 4B is an example of a list of candidate data sources associated with a data request.

(7) FIG. 5 shows an example of an AI model training flow chart.

(8) FIG. 6 is a functional block diagram of a computing device that may execute the techniques described herein.

DETAILED DESCRIPTION OF EMBODIMENTS

(9) The present disclosure relates generally to the field of predictive analytics, data processing, and data management. In particular, the present disclosure relates to using machine learning models to route data to data sources.

(10) While principles of the present disclosure are described herein with reference to illustrative embodiments for particular applications, it should be understood that the disclosure is not limited thereto. Those having ordinary skill in the art and access to the teachings provided herein will recognize additional modifications, applications, embodiments, and substitution of equivalents all fall within the scope of the embodiments described herein. Accordingly, the embodiments are not to be considered as limited by the foregoing description.

(11) Various non-limiting embodiments of the present disclosure will now be described to provide an overall understanding of the principles of the structure, function, and use of systems and methods disclosed herein for using machine learning models to identify data sources best suited for filling documentation gaps associated with a data request.

(12) Conventional rule-based methods fail to efficiently and cost-effectively identify data sources best suited for filling documentation gaps associated with a data request, and result in an increase

of network traffic (and a corresponding reduction in network bandwidth) based on multiple, and sometimes redundant data requests being transmitted to more data sources than necessary to fill the documentation gaps. The conventional methods are frequently tedious, subjective, time consuming, error-prone, and expensive. It is technically challenging to develop methods that maximize high-speed, quality, and fidelity sources in an affordable manner and meet needs in view of cost, timeliness, regulatory compliance, quality, and age of data.

(13) The present disclosure provides embodiments that address the above shortcomings in the field of predictive analytics, data processing, and data management, leading to significant technical improvements in the same field. For instance, a system of one or more artificial intelligence (AI) agents **110** discussed in the present disclosure overcomes the technical shortcomings of the conventional techniques by determining a ranking value for one or more candidate data sources for a data request, and routing data requests over a network to certain candidate data sources based on the ranking values for the candidate data sources, and blocking the routing of data requests over the network to other candidate data sources based on the ranking values for the candidate data sources. This allows for avoiding duplicating data requests, reducing unnecessary backlogs to network traffic due to redundant data requests, and reducing computational resources, such as, e.g., processing and storage cost, where data is available through multiple data sources in an efficient and expeditious manner, without the shortcomings of the conventional, rule-based approach discussed above. The disclosed techniques leads to further technical advancements in the technological fields discussed above, including the expeditious and accurate assessment of data sources at which a data request may be fulfilled by way of predictive analytics, the easing of congestion over networks as the traffic is reduced commensurate with the reduction in unnecessary data requests, and the automation of documentation gap-related remedial actions based on the results of the data source assessment. Because the identification of most efficient data sources can be achieved expeditiously and accurately, the subsequent documentation gap-related remedial actions are also performed in an expeditious, accurate manner, leading to a fast resolution of documentation gaps without wasting unnecessary computational resources associated with duplicated data requests, network communications (e.g., network bandwidth usage), data processing, and others.

(14) Advantageously, the AI agent(s) **110** include a plurality of agents **110**, each agent including a cognitive model, that run in parallel to evaluate a data object associated with the data request. The data object is input by a user and can sometimes include an extremely large number of entries, and each entry in the data object often includes different attributes to be evaluated by the AI agent(s) to determine a suitable data source to accommodate the entry. In some examples, each AI agent **110** is a Soar cognitive agent and is included within a Python-coded “worker” process. In these examples, each Python process creates its own instance of an AI agent, collects input tasks in the form of entries within a data object, forwards those tasks to the AI agent **110**, receives and parses outputs from the AI agent **110**, and then sends the results from the AI agent **110** to an output queue. The number of AI agents **110** is designed to scale according to the number of entries within a data object.

(15) The above technical improvements, and additional technical improvements, will be described in detail throughout the present disclosure. Also, it should be apparent to a person of ordinary skill in the art that the technical improvements of the embodiments provided by the present disclosure are not limited to those explicitly discussed herein, and that additional technical improvements exist.

(16) FIG. 1 is a diagram showing an example of an environment **100** for identifying data sources best suited for filling documentation gaps associated with a data request, according to some embodiments of the disclosure. A client device **102** associated with a user communicates with one or more other components of the environment **100** across a network **104**, including one or more server-side systems **106**. The server-side systems **106** may be local or remote file servers, cloud-

based storage services, or other forms of computer systems.

(17) The server-side systems **106** include server-side computing device(s) **108**, AI agent(s) **110**, and/or one or more data storage system(s) **116**, among other systems. In some examples, the AI agent(s) **110** include an input/output module **112** and a cognitive model **114**. The data storage system(s) **116** include one or more data stores or data sources.

(18) In some examples, the server-side computing device(s) **108**, the AI agent(s) **110**, and/or the data storage system(s) **116** are associated with a common entity/organization (e.g., a healthcare provider or other institution) and are part of a cloud service computer system (e.g., in a data center). That is, the various systems can be components or subsystems of a larger computer system. In other examples, one or more of the server-side computing device(s) **108**, the AI agent(s) **110**, and/or the data storage system(s) **116** are separate systems associated with different entities. In such examples, each of the separate systems are communicatively connected to one another over the network **104** (e.g., via an application programming interface (API)). The systems and devices of the environment **100** can communicate in any arrangement. As discussed herein, systems and/or devices of the environment **100** communicate in order to facilitate processing of data objects, particularly the identification of data sources best suited for filling documentation gaps associated with a data request.

(19) The client device **102** is configured to enable the user to access and/or interact with other systems in the environment **100**. In some examples, the user is associated with (e.g., is an employee or contractor of) the organization. The client device **102** is a computer system such as, for example, a desktop computer, a laptop computer, a tablet, a smart cellular phone, a smart watch, or other wearable computer, etc. The client device **102** includes one or more applications **118**, e.g., an application programming interface (API), program, plugin, browser extension, etc., installed on a memory of the client device **102**.

(20) In some embodiments, at least one of the applications is associated and configured to communicate with one or more of the other components in the environment **100**, such as one or more of the server-side systems **106**. For example, the at least one application **118** can be executed on the client device **102** to communicate with the server-side computing device(s) **108** to transmit a data request and/or a data object.

(21) Additionally, one or more components of the client device **102**, such as the at least one application **118**, generate, or cause to be generated, one or more graphic user interfaces (GUIs) based on instructions/information stored in the memory, instructions/information received from the other systems in the environment **100**, and/or the like and cause the GUIs to be displayed via a display of the client device **102**. The GUIs can be, e.g., mobile application interfaces or browser user interfaces and include text, input text boxes, selection controls, and/or the like. In some examples, the display includes a touch screen or a display with other input systems (e.g., a mouse, keyboard, etc.) to control the functions of the client device **102**.

(22) The server-side computing device(s) **108** include one or more server devices (or other similar computing devices) for executing services associated with an organization. The services can include both user-facing services as well as internal services.

(23) In some examples, the AI agent(s) **110** is a system of (e.g., is hosted by) the same entity/organization associated with the server-side computing device(s) **108**. In such examples, the AI agent(s) **110** can be a sub-system or component of the server-side computing device(s) **108**. In other examples, the AI agent(s) **110** is a system of (e.g., is hosted by) a third party that provides services for identifying data sources best suited for filling documentation gaps associated with a data request to the entity/organization associated with the server-side computing device(s) **108**.

(24) The AI agent(s) **110** includes one or more server devices (or other similar computing devices) for executing processes for identifying data sources best suited for filling documentation gaps associated with a data request. As described in detail elsewhere herein, example processes for identifying data sources best suited for filling documentation gaps associated with a data request

include: receiving a user input including a data request from a user device, wherein the data request includes a data object including one or more entities and one or more attributes; receiving an input list of one or more candidate data sources for the data request; determining, by an artificial intelligence (AI) model (e.g., one or more AI agents performing operations in parallel, each of the one or more AI agents including a cognitive model), a ranking value for each of the one or more candidate data sources based on the one or more attributes; sorting, by the AI model, the one or more candidate data sources by the ranking value for each of the one or more candidate data sources; and transmitting, to the user device, an output list of the one or more candidate data sources for the data request sorted by the ranking value for each of the one or more candidate data sources

(25) The data storage system(s) **116** each include a server system or computer-readable memory such as a hard drive, flash drive, disk, etc. The data stores of the data storage system(s) **116** include and/or act as a repository or source for various types of data objects.

(26) In some examples, one of the data storage system(s) **116** maintains each of the data stores. In other examples, one or more of the data stores are maintained across two or more different ones of the data storage system(s) **116**. One or more of the data storage system(s) **116** can be a system of (e.g., hosted by) the same entity/organization associated with the server-side computing device(s) **108** and/or AI agent(s) **110**. Additionally or alternatively, one or more of the data storage system(s) **116** are associated with a third party that provides data storage services to the entity/organization and/or AI agent(s) **110**.

(27) The network **104** over which the one or more components of the environment **100** communicate includes one or more wired and/or wireless networks, such as a wide area network (“WAN”), a local area network (“LAN”), personal area network (“PAN”), a cellular network (e.g., a 3G network, a 4G network, a 5G network, etc.) or the like. In some embodiments, the network **104** includes the Internet, and information and data provided between various systems occurs online. “Online” means connecting to or accessing source data or information from a location remote from other devices or networks coupled to the Internet. Alternatively, “online” refers to connecting or accessing a network (wired or wireless) via a mobile communications network or device. The Internet is a worldwide system of computer networks—a network of networks in which a party at one computer or other device connected to the network can obtain information from any other computer and communicate with parties of other computers or devices. The client device **102** and one or more of the server-side systems **106** are connected via the network **104**, using one or more standard communication protocols. The client device **102** and the one or more of the server-side systems **106** transmit and receive communications from each other across the network **104**.

(28) Although depicted as separate components in FIG. 1, it should be understood that a component or portion of a component in the system of the environment **100** is, in some embodiments, integrated with or incorporated into one or more other components. As one example, the input/output module **112** and cognitive model **114** can be integrated into a single component or sub-system of the AI agent(s) **110**. In some embodiments, operations or aspects of one or more of the components discussed above are distributed amongst one or more other components. Any suitable arrangement and/or integration of the various systems and devices of the environment **100** can be used.

(29) In the following disclosure, various acts are described as performed or executed by a component represented in FIG. 1, such as the client device **102** or one or more of the server-side systems **106**, or components thereof. However, it should be understood that in various aspects, various components of the environment **100** discussed above execute instructions or perform acts including the acts discussed below. An act performed by a device is considered to be performed by one or more processors, actuators, or the like associated with that device. Further, it should be understood that in various embodiments, various steps can be added, omitted, and/or rearranged in any suitable manner.

(30) The functioning of the AI agent(s) **110** will now be described in more detail with regard to FIGS. 2-4B. FIG. 2 is a flowchart of an example process for identifying data sources best suited for filling documentation gaps associated with a data request. FIG. 3 is also a flowchart of an example process for using an AI model to rank data sources best suited for filling documentation gaps associated with a data request. The processes described in FIGS. 2 and 3 will be described with reference to FIGS. 4A and 4B.

(31) FIG. 4A provides an example data object **400** comprising the data request. The data object **400** includes one or more entries **402**, and one or more user-input attributes, which are selected from value attributes **404** and binary attributes **406**.

(32) The data request is made in the context of an organization and a tenant. In some examples, an organization can be a company or corporation or a division within a larger company or corporation. The user can enter information for organizations through, for example, an API interface in communication with the input/output module **112** of the AI agent **110**, and subsequent data requests may be populated with options of organizations to choose from based on user inputs. The input/output module **112** receives from the user a universally unique identifier (UUID), and the user provides other metadata for the organization associated with the data request, such as a name for the organization, a contact name and e-mail address, a description of the organization, etc.

(33) When creating the data request, the user creates a tenant through the API interface in communication with the input/output module **112** of the AI agent **110**, where the tenant is an isolated container with software and data within the scope of a selected organization. An organization list can be populated based on the user identified organizations for the user to choose from. A tenant can be saved to a store with an associated organization's UUID for future use. A user can create one or more “projects” within a data request in the context of a tenant. In some examples, each project within a data request may be associated with an organization, a tenant, and one or more attributes. A project is created under the context of a tenant and holds attribute weights and data sources. This project configuration can be associated with one or multiple data sources submitted in the context of a tenant.

(34) In some examples, the data object **400** is a roster of members in a healthcare cohort, where the entries **402** are members (e.g., patients) in the healthcare cohort. The value attributes **404** can be, for example, data relating to a purpose of use for the roster, such as risk adjustment or quality, general attributes such as the speed or ease of use of the data source. The binary attributes **406** are specific data that a user requires the data source to include. For example, one binary attribute can be body mass index (BMI). Selecting a binary attribute such as BMI is an indication by a user that the preferred data sources should be those that include data for BMI.

(35) Once a tenant is created by the user, a list of candidate data sources is created within the context of the tenant and the data request. Users can create entries for data sources associated with tenants, such that a data request associated with a tenant can be pre-populated with a list of candidate data sources. FIG. 4B is an example of a list **410** of candidate data sources associated with a data request. In the example shown in FIG. 4B, the list **410** includes, arranged in a matrix that can be default or defined by a user, the candidate data sources **412**, a first cost attribute **414**, a first value attribute **416**, a second value attribute **418**, a third value attribute **420**, a second cost attribute **422**, a first binary attribute **424**, a second binary attribute **426**, a total cost attribute **428**, and a total value attribute **430**. In some examples where the data object **400** is a roster of members in a healthcare cohort, the first cost attribute **414** is a per member per year (PMPY) cost, the first value attribute **416** is a measure of the risk adjustment data of the data sources, the second value attribute **418** is a quality of the data, the third value attribute **420** is a measure of the speed with which the data is delivered, the second cost attribute **422** is a storage and processing cost, the first binary attribute **424** is a Yes/No value identifying whether the data in the data source includes a certain type of data (e.g., health/medical data such as, e.g., colonoscopy data), and the second binary attribute **426** is a Yes/No value identifying whether the data in the data source includes

another type of data (e.g., health/medical data such as, e.g., BMI data). The total cost attribute **428** is a numerical sum of the first cost attribute **414** and the second cost attribute **422**. The total value attribute **430** is a sum of a score for each of first value attribute **416**, second value attribute **418**, and third value attribute **420**. More or fewer attributes can be included without diverging from the scope of this disclosure, and the number of attributes in FIGS. **4A** and **4B** are for example purposes only. The model has the capability of incorporating information about whether the user already has a contract with a data source for a particular member entry in the data object that could be purchased from that data source. If so, the invention automatically adjusts the first cost attribute **414** (PMPY) for that member for that data source to be 0.

(36) The value attributes are generally subjective attributes that may be scored by a user or an AI model. In some examples, the value attributes may be scored on a scale of 1-5, with a higher score corresponding to a higher suitability for a data source for the value attribute. For example, the scores can be calculated as follows: Fair—1 Good—2 Very Good—3 Great—4 Excellent—5

(37) The candidate data sources can be, for example, any of the following file types: Flat file (similar to CCD with delimited or fixed width file format); ADT or ORU (HL7 v2.x); HL7 v2.x VXU; C-CDA/CCD (HL7 v3.x); FHIR Resource (HL7 v4.x); or API (RESTful web services).

(38) With reference to FIG. **2**, a process **200** for identifying data sources best suited for filling documentation gaps associated with a data request is described. Process **200** can be performed by the server-side systems **106** or the components therein (e.g., one or more AI agents **110**).

(39) At block **202**, the process **200** can include receiving, from a user device, a user input including a data request associated with one or more data gaps (e.g., documentation gaps, etc.), the data request including a data object including one or more entities and one or more attributes associated with each of the one or more entities. As discussed above, FIG. **4A** provides an example data object **400** included in a data request. The data object **400** includes one or more entries **402**, and one or more user-input attributes, which are selected from value attributes **404** and binary attributes **406**. In some examples, the data object **400** represent a roster of members (e.g., patients) in a healthcare cohort, where each entry **402** is associated with a member in the healthcare cohort. The value attributes **404** can be, for example, data relating to a purpose of use for the roster, such as risk adjustment or quality. The binary attributes **406** indicate specific data that a user requires the data source to include. For example, one binary attribute can be body mass index (BMI). Selecting a binary attribute such as BMI is an indication by a user that the preferred data sources should be those that include data for BMI.

(40) At block **204**, the process **200** can include receiving an input list including a plurality of candidate data sources for the data request. The candidate data sources may be user-defined or automatically generated by the AI agents **110** based on historical data. FIG. **4B** depicts an example of a list **410** of data sources.

(41) At block **206**, the process **200** can include determining, by an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request. Determining the ranking value is described in greater detail with reference to FIG. **3** below, and includes at least: (i) filtering by the binary attributes; (ii) sorting by the binary attributes; and (iii) sorting by weighted value attributes.

(42) At block **208**, the process **200** includes sorting, by the AI model, the plurality of candidate data sources by the plurality of ranking values. This includes producing an output list of the candidate data sources sorted from highest ranking value to lowest ranking value. In some examples, the ranking value for each data source is a relative value that is dependent on the other data sources. For example, if there are N data sources, the highest ranking value will be N and the lowest ranking value will be 1. The output list sorts the data sources in order of these ranking values. Once the one or more candidate data sources are sorted by the ranking value, an output list of the ranked one or more candidate data sources is generated, for transmission to the user device.

(43) At block **210**, the process **200** includes, in response to receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources. The output list can be provided via the input/output module **112** for display at the user device and can include all candidate data sources that were not excluded in the filtering process, or can include a specific number of the highest ranked data sources, e.g., the three highest ranked data sources. A user can use the output list to further investigate the costs, quality, fidelity, etc., of the highest ranked data sources to more efficiently identify and select an optimal data source for the input data request. In some examples, the AI agent(s) **110** may automatically initiate a retrieval of data from the highest ranked data source, with or without requiring approval from a user.

(44) In an example, the process **200** further includes, in response to receiving, from the user device, a response to the output list: routing, over a network, the data request to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value. In some examples, this includes dropping or excluding, from the output list, one or more of the plurality of candidate sources with a ranking value below a predetermined threshold. The predetermined threshold is selected by a user and may reflect a relative value or a general value. An example of a relative value includes, e.g., the top three ranked candidate data sources exceed a predetermined threshold, and all others are below the predetermined threshold, the predetermined threshold being defined as “top three.” Alternative, the rankings can comprise numerical values, e.g., on a scale of 0 to 10, and the predetermined threshold may be set to a value between 0 and 10. For example, a predetermined threshold is set at 5 and all candidate sources with a raw score of less than 5 are dropped.

(45) Moreover, the process **200** includes other remedial actions in response to the identification of highest ranked candidate data sources, such as updating the data object **400** in a format associated with the candidate data source with a highest ranking value, prior to routing the data request to that candidate data source. This would allow for efficient and streamlined filling of documentation gaps in data object **400** from the candidate source with the highest ranking value. In another example, the process **200** includes generating the data object **400** in the format associated with a candidate data source, and automatically retrieving the data from the candidate data source and automatically filling documentation gaps in the data object **400** with the data retrieved from the candidate data source.

(46) Additionally, the process **200** can include automatically routing, over a network, the data request to at least a first candidate data source of the plurality of candidate data sources based on the ranking values determined for the plurality of candidate data sources. For example, the process **200** may include routing a data request to be sent over the network to the candidate sources with the highest ranking values, such as the highest one, two, or three ranking values. Similarly, the process **200** can include blocking routing of the data request over the network to at least a second candidate data source of the one or more candidate data sources based on the ranking values determined for the plurality of candidate data sources, wherein the ranking value for the first candidate data source is higher than the ranking value for the second candidate data source. In response to the data request, the candidate source fulfills the data request by extracting and transmitting relevant data to the server-side systems **106**, which the server-side systems **106** use to automatically fill the identified documentation gaps in the data object **400**.

(47) FIG. 3 is a flowchart of an example process for using an AI model (e.g., one or more AI agents performing operations in parallel, each of the one or more AI agents including a cognitive model) to rank data sources best suited for filling documentation gaps associated with a data request. In particular, FIG. 3 describes a process **300** for determining a ranking value for each of the one or

more candidate data sources based on one or more attributes. The process **300** is performed on one entry **402** at a time by the AI agent(s) **110**, or is performed on multiple entries in parallel. The process **300**, in this example, begins by determining whether any binary attributes are included for an entry. In one example, the process **300** will be demonstrated for entry **2** in FIG. **4A**. A user has identified the first binary attribute **424** (Binary 1) among the binary attributes **406** required in data object **400** for entry **2**. In other examples, the operations in process **300** may be interchanged and performed in a different order. Steps may be added, removed, or re-arranged to methods described within the scope of the present disclosure.

(48) At block **302**, process **300** includes, upon determining that a candidate data source does not include an entry for each of the binary attributes, filtering the candidate data source from the output list. In the example shown in FIGS. **4A** and **4B**, this would result in filtering data source **1**, data source **3**, data source **4**, and data source **6** out of the output list for entry **2**, as these data sources do not include a data entry for the first binary attribute **424** (Binary 1). At this point, the output list is {2, 5, 7, 8, 9}. The curly brackets indicate an unsorted list, as all the data sources have the same relative value as of the process step performed in block **302**. Namely, they all include a data entry for the first binary attribute **424**, which was indicated as a necessary binary attribute in data object **400**.

(49) At block **304**, the process **300** includes sorting the candidate data sources by the total number of entries for at least one of the one or more binary attributes. In the example shown in FIGS. **4A** and **4B**, this comprises sorting data sources {2, 5, 7, 8, 9} by those that have a data entry for the second binary attribute **426**. Note that binary attribute was not indicated as a necessary binary attribute for entry **2** in data object **400**. As such, no action is performed for entry **2** at block **304** and the output list after the step performed in block **304** remains unchanged.

(50) At block **306**, the process **300** includes sorting the candidate data sources by total cost. Procuring data from data sources can be expensive, such that sorting by total cost constitutes a high priority. Often, there are many cost factors associated with procuring data. In list **410**, a first cost attribute **414** and a second cost attribute **422** are shown. These attributes should be in consistent units, such as USD. A total cost attribute **428** is calculated by summing the first cost attribute **414** and the second cost attribute **422** in a pre-processing step. As such, the output list is sorted by the total cost attribute **422** at block **306**. As a result, the output list after the step performed in block **306** is [2, 7, 8, {5, 9}]. Sorting by total cost comprises sorting by lowest cost to highest cost. Further, the sorting was performed separately for data sources **2**, **7**, **8**, and data sources **5** and **9** based on the results of the sorting performed in block **304**. Subsequent sorting steps are performed to differentiate unsorted data sources. As a result, data sources **2**, **7**, and **8** are the top three data sources, in that order. Any subsequent sorting steps will be used to differentiate data sources **5** and **9**. Total cost is one of the weighted attributes and can be used in any order relative to the other attributes. Because it is a different data type, which is minimized rather than maximized, it does not share a weight with any other attributes and is subject to different processing logic. However, in other examples, it is set by the user to be prioritized last rather than first, or somewhere in the middle.

(51) At block **308**, the process **300** proceeds to sorting the candidate data sources by a highest weighted value attribute. A user defines value attributes by a weight. The weights may be absolute or relative. In other words, a user designates weights as, for example, “high,” “medium,” “low,” etc., with attributes of equal weight being treated equally, the weights being absolute. For weighted attributes, the user is able to configure multiple attributes with equal weights, not just unique or relative weights. For example, if Value 2 and Value 3 have the same weight, and data source **1** has values [Excellent] and [Fair] for each, respectively, and data source **2** has values [Great] and [Very Good], sorting by best average value would give preference to data source **2**, while best maximum value would give preference to data source **1**. Alternatively, a user designates weight as relative. For example, for entry **1** in data object **400**, a user has indicated value attributes value 1 and value 2

as value attributes of interest, and can assign weights to them either as: value 1: high, value 2: high, or value 1: high, value 2: low, or sort them by relative weights, e.g.: highest value 1, next highest value 2. If a user had indicated the first value attribute **1** as the highest weighted value attribute, first the candidate data sources would be sorted by value attribute **1**. Because data sources **5** and **9** have the same value for value attribute **1** (“Fair”), the output list is unaltered by the step performed in block **308**. As a result, the output list after the step performed in block **308** remains [2, 7, 8, {5, 9}].

(52) At block **310**, the process **300** includes sorting the candidate data sources by a next highest weighted value attribute. As such, the candidate data sources are sorted by value attribute **2**. Because data source **9** is “Excellent” while data source **5** is “Very Good,” data source **9** is thus sorted ahead of data source **5**. As a result, the output list after the step performed in block **308** is [2, 7, 8, 9, 5].

(53) Similar processes **300** can be performed on entries **1**, **3**, and **4** to arrive at the following output lists for the other entries. Entry **1**: [2, 7, 8]. Entry **3**: [2, 1, 7, 8]. Entry **4**: [2, 1, 6, 5, 9, 3, 4, 7, 8]. In the example of entry **4**, the data sources **1**, **5**, and **9** are sorted by total value attribute **430** as a final step as no weights are provided for any of the value attributes **416-420**.

(54) Output processing in some examples includes aggregating the output data source rankings generated per entry of the data object to yield a single recommendation to the user for which data sources they can use to satisfy the entire data request. For example, the output takes the form “use data sources X, Y, Z to satisfy all entries of the data object” and “using just these data sources vs the whole default set of data sources will save ~\$X”. To aid in tying the data acquired from the data sources to the entries in the data request, metadata may be used to track the entries. This metadata can include, for example, a Unique Roster Identifier (Roster ID) for the data object, Total number of entries, Date and Timestamp when a status (e.g., a data request) began, Date and Timestamp when the status ended, Begin Status (e.g., Basic Validation In-Progress, De-Duplication In-Progress, Member Validation In-Progress, Agent Processing In-Progress), End Status (e.g., Basic Validation Completed, De-duplication Completed, Member Validation Completed, Processing Completed), Total number of duplicates, Total number of error records (validation failed), Total number of error records (agent processing failed), Total records successfully processed, Reconciliation of total member records (e.g., Total records successfully processed+duplicates+error records (validation failure)+error records (agent processing failure)+missed records).

(55) Each output file from the data request can also include metadata with information relating to, for example, an Initial Roster file, Files with the duplicate records, Files with the non-duplicate records, File with member validation failed records (with error information), Files with member validation successful records, Files with agent processing failed records (with error information), and Successful records for each data source (recommendation files-output roster files, the final output files).

(56) The error details in the metadata can include, for example, an error code, an error field if applicable, a user-friendly error message, and error details (e.g., a system message). An additional sorting step is included in some examples, in which the AI agent(s) sort data sources based on how confident the tool is that the data source actually has the desired data for that member. This step can be inserted before or after sorting by binary attributes or weighted attributes. In some examples, it is a special case of the weighted attribute sorting step where the confidence metric is considered a case of any other attribute. Similarly, the binary attribute sort step is, in some examples, a special case of weighted attribute sorting with the extra feature that it can filter out a data source if it has a 0 score.

(57) FIG. 5 shows an example machine learning training flow chart **500**, according to some embodiments of the disclosure. Referring to FIG. 5, a given machine learning model, such as the cognitive model **114** of AI agent(s) **110**, is trained using the training flow chart **500**. The training data **510** includes one or more of stage inputs **512** and the known outcomes **514** related to the

machine learning model to be trained. The stage inputs **512** are from any applicable source, including text, visual representations, data, values, comparisons, and stage outputs, e.g., one or more outputs from one or more steps from FIGS. 2-3. For example, the stage inputs **512** may include data source rankings associated with particular data requests. The known outcomes **514** are included for the machine learning models generated based on supervised or semi-supervised training or can be based on known labels, such as review classification labels. An unsupervised machine learning model is not trained using the known outcomes **514**. The known outcomes **514** include known or desired outputs for future inputs similar to or in the same category as the stage inputs **512** that do not have corresponding known outputs.

(58) The training data **510** and a training algorithm **520**, e.g., one or more of the modules implemented using the machine learning model or used to train the machine learning model, are provided to a training component **530** that applies the training data **510** to the training algorithm **520** to generate the machine learning model, e.g., the cognitive model **114**. According to an implementation, the training component **530** is provided with comparison results **516** that compare a previous output of the corresponding machine learning model to apply the previous result to re-train the machine learning model. The comparison results **516** are used by the training component **530** to update the corresponding machine learning model. In addition to a cognitive model, in some examples, the training algorithm **520** utilizes machine learning networks or models including, but not limited to, deep learning networks such as Deep Neural Networks (DNN), Convolutional Neural Networks (CNN), Fully Convolutional Networks (FCN), and Recurrent Neural Networks (RCN), probabilistic models such as Bayesian Networks and Graphical Models, classifiers such as K-Nearest Neighbors, or discriminative models such as Decision Forests and maximum margin methods, the model specifically discussed herein, or the like.

(59) The cognitive models **114** used herein are trained to learn to adjust the values assigned to different data sources (low, medium, high, etc) for different attributes based on those data sources' performance. The content that the model is trained on varies, in some examples, to include learning different values for different data sources' attributes (to be used during sorting), learning the likelihood of a data source satisfying a binary attribute to allow for sorting and filtering by the binary attribute, and learning special case logic for sorting data sources in particular scenarios, for example for changing the order of sorting steps in special cases.

(60) The initial training of the machine learning models may be completed by utilizing data that has been tagged. In some embodiments, this tagged data serves as an input for supervised or semi-supervised learning approaches. The tagging process can be done manually or automatically, depending on the desired level of accuracy and available resources.

(61) Manual tagging involves human annotators who examine training data and assign appropriate classification labels based on the content and context of the training data. This method can yield high-quality labeled data, as humans can understand nuances and contextual information better than automated algorithms. However, manual tagging can be time-consuming and labor-intensive, especially when dealing with large datasets.

(62) Automatic tagging, on the other hand, involves using algorithms, such as natural language processing techniques or pre-trained machine learning models, to assign classification labels to reviews. This approach is faster and more scalable than manual tagging but may not be as accurate, particularly when dealing with complex or ambiguous items. To improve the accuracy of automatic tagging, it can be combined with manual tagging in a semi-supervised learning approach, where a smaller set of manually tagged data is used to guide the automatic tagging process.

(63) The data collection process can be done manually or using web-scraping techniques. Manual data collection can be time-consuming and may not cover all the available data sources. Web-scraping techniques, on the other hand, use automated tools and scripts to extract data from various sources, making the process faster and more comprehensive.

(64) Once data has been collected and tagged with appropriate classification labels, it can be used

as input for the machine learning model's training process. The model will learn to recognize patterns and features in the data that correspond to specific contexts for data. With sufficient training and accurate labeled data, the machine learning model can become adept at identifying context-specific outputs, enabling an efficient and effective model.

(65) It should be understood that embodiments in this disclosure are examples only, and that other embodiments may include various combinations of features from other embodiments, as well as additional or fewer features.

(66) In general, any process or operation discussed in this disclosure that is understood to be computer-implementable, such as the processes illustrated in FIGS. 2-3, may be performed by one or more processors of a computer system, such any of the systems or devices in the environment **100** of FIG. 1, as described above. A process or process step performed by one or more processors may also be referred to as an operation. The one or more processors may be configured to perform such processes by having access to instructions (e.g., software or computer-readable code) that, when executed by the one or more processors, cause the one or more processors to perform the processes. The instructions may be stored in a memory of the computer system. A processor may be a central processing unit (CPU), a graphics processing unit (GPU), or any suitable types of processing unit.

(67) A computer system, such as a system or device implementing a process or operation in the examples above, may include one or more computing devices, such as one or more of the systems or devices in FIG. 1. One or more processors of a computer system may be included in a single computing device or distributed among a plurality of computing devices to perform a computer-implemented method. A memory of the computer system may include the respective memory of each computing device of the plurality of computing devices.

(68) FIG. 6 is a simplified functional block diagram of a computer **600** that may be configured as a device for executing the methods of FIGS. 1-5, according to example embodiments of the present disclosure. In various embodiments, any of the systems herein may be a computer **600** including. The computer **600** also may include a central processing unit ("CPU") **602**, in the form of one or more processors, for executing program instructions. The computer **600** may include an internal communication bus **608**, and a storage unit **606** (such as ROM, HDD, SSD, etc.) that may store data on a computer readable medium **622**, although the computer **600** may receive programming and data via network communications (e.g., via network **140**). The computer **600** may also have a memory **604** (such as RAM) storing instructions **624** for executing techniques presented herein, although the instructions **624** may be stored temporarily or permanently within other modules of computer **600** (e.g., processor **602** or computer readable medium **622**). The computer **600** also may include input and output ports **612** or a display **610** to connect with input and output devices such as keyboards, mice, touchscreens, monitors, displays, etc. The various system functions may be implemented in a distributed fashion on a number of similar platforms, to distribute the processing load. Alternatively, the systems may be implemented by appropriate programming of one computer hardware platform.

(69) Program aspects of the technology may be thought of as "items" or "articles of manufacture" typically in the form of executable code or associated data that is carried on or embodied in a type of machine-readable medium. "Storage" type media include any or all of the tangible memory of the computers, processors or the like, or associated modules thereof, such as various semiconductor memories, tape drives, disk drives and the like, which may provide non-transitory storage at any time for the software programming. All or portions of the software may at times be communicated through the Internet or various other telecommunication networks. Such communications, for example, may enable loading of the software from one computer or processor into another, for example, from a management server or host computer of the mobile communication network into the computer platform of a server or from a server to the mobile device. Thus, another type of media that may bear the software elements includes optical, electrical and electromagnetic waves,

such as used across physical interfaces between local devices, through wired and optical landline networks and over various air-links. The physical elements that carry such waves, such as wired or wireless links, optical links, or the like, also may be considered as media bearing the software. As used herein, unless restricted to non-transitory, tangible “storage” media, terms such as computer or machine “readable medium” refer to any medium that participates in providing instructions to a processor for execution.

(70) While the disclosed methods, devices, and systems are described with reference to transmitting data, it should be appreciated that the disclosed embodiments may be applicable to any environment, such as a desktop or laptop computer, an automobile entertainment system, a home entertainment system, etc. Also, the disclosed embodiments may be applicable to any type of Internet protocol.

(71) It should be appreciated that in the above description of embodiments of the disclosure, various features of the disclosure are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of one or more of the various inventive aspects. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed embodiment requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment. Thus, the claims following the Detailed Description are hereby expressly incorporated into this Detailed Description, with each claim standing on its own as a separate embodiment of this disclosure.

(72) Furthermore, while some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the disclosure, and form different embodiments, as would be understood by those skilled in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

(73) Thus, while certain embodiments have been described, those skilled in the art will recognize that other and further modifications may be made thereto without departing from the spirit of the disclosure, and it is intended to claim all such changes and modifications as falling within the scope of the disclosure. For example, functionality may be added or deleted from the block diagrams and operations may be interchanged among functional blocks. Steps may be added or deleted to methods described within the scope of the present disclosure.

(74) The above disclosed subject matter is to be considered illustrative, and not restrictive, and the appended claims are intended to cover all such modifications, enhancements, and other implementations, which fall within the true spirit and scope of the present disclosure. Thus, to the maximum extent allowed by law, the scope of the present disclosure is to be determined by the broadest permissible interpretation of the following claims and their equivalents, and shall not be restricted or limited by the foregoing detailed description. While various implementations of the disclosure have been described, it will be apparent to those of ordinary skill in the art that many more implementations are possible within the scope of the disclosure. Accordingly, the disclosure is not to be restricted except in light of the attached claims and their equivalents.

(75) Example 1. A computer-implemented method comprising: receiving, by one or more processors and from a user device, a user input including a data request associated with one or more data gaps, wherein the data request includes a data object including one or more entities and one or more attributes associated with each of the one or more entities; receiving, by the one or more processors, an input list including a plurality of candidate data sources for the data request; determining, by the one or more processors and an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; sorting, by the one or more processors and the AI model, the plurality of candidate data sources by the plurality of ranking values; in response to

receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources; in response to receiving, by one or more processors and from the user device, a response to the output list: routing, by the one or more processors and over a network, the data request to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking, by the one or more processors, routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value.

(76) Example 2. The computer-implemented method of example 1, wherein the one or more attributes include one or more binary attributes, and wherein determining the ranking value for each of the plurality of candidate data sources comprises: determining whether each of the plurality of candidate data sources includes an entry for each of the one or more binary attributes; and upon determining that at least one of the plurality of candidate data sources does not include an entry for each of the one or more binary attributes, filtering the at least one of the plurality of candidate data sources from the output list.

(77) Example 3. The computer-implemented method of example 2, wherein determining the ranking value for each of the plurality of candidate data sources further comprises: upon determining that two or more of the plurality of candidate data sources include an entry for at least one of the one or more binary attributes, sorting the two or more of the plurality of candidate data sources by a total number of entries for at least one of the one or more binary attributes.

(78) Example 4. The computer-implemented method of any of examples 1-3, wherein the one or more attributes include one or more cost attributes, and wherein determining the ranking value for each of the plurality of candidate data sources comprises: determining a total cost based on the one or more cost attributes for each of the plurality of candidate data sources; and sorting the plurality of candidate data sources by the total cost.

(79) Example 5. The computer-implemented method of any of example 1-4, wherein the one or more attributes include one or more user-input value attributes, each of the one or more user-input value attributes including a user-defined weight, and wherein determining the ranking value for each of the plurality of candidate data sources comprises: sorting the plurality of candidate sources by the one or more user-input value attributes.

(80) Example 6. The computer-implemented method of any of examples 1-5, wherein the attributes include two or more user-input value attributes, and wherein determining the ranking value for each of the plurality of candidate data sources comprises: sorting the plurality of candidate sources by the user-input value attribute with a highest user-defined weight; and sorting the plurality of candidate sources by the user-input value attribute with a next highest user-defined weight.

(81) Example 7. The computer-implemented method of any of examples 1-6, wherein the output list includes a predetermined number of candidate data sources, wherein the predetermined number of candidate data sources included in the output list are candidate data sources with highest ranking values.

(82) Example 8. The computer-implemented method of any of examples 1-7, wherein the AI model comprises a plurality of AI agents performing operations in parallel, each of the AI agents including a cognitive model.

(83) Example 9. The computer-implemented method of any of examples 1-8, wherein the one or more attributes include one or more of: binary attributes; cost attributes; or value attributes.

(84) Example 10. The computer-implemented method of any of examples 1-9, further comprising: prior to routing the data request to the first candidate data source, updating, by the one or more processors, the data object in a format associated with the first candidate data source.

(85) Example 11. A system comprising: memory configured to store instructions; and one or more processors configured to execute the instructions to perform operations comprising: receiving, from

a user device, a user input including a data request associated with one or more data gaps, wherein the data request includes a data object including one or more entities and one or more attributes associated with each of the one or more entities; receiving an input list including a plurality of candidate data sources for the data request; determining, by an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; sorting, by the AI model, the plurality of candidate data sources by the plurality of ranking values; in response to receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources; in response to receiving, from the user device, a response to the output list: routing the data request over a network to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value.

(86) Example 12. The system of example 11, wherein the one or more attributes include one or more binary attributes, and wherein determining the ranking value for each of the plurality of candidate data sources comprises: determining whether each of the plurality of candidate data sources includes an entry for each of the one or more binary attributes; and upon determining that at least one of the plurality of candidate data sources does not include an entry for each of the one or more binary attributes, filtering the at least one of the plurality of candidate data sources from the output list.

(87) Example 13. The system of example 12, wherein determining the ranking value for each of the plurality of candidate data sources further comprises: upon determining that two or more of the plurality of candidate data sources include an entry for at least one of the one or more binary attributes, sorting the two or more of the plurality of candidate data sources by a total number of entries for at least one of the one or more binary attributes.

(88) Example 14. The system of any of examples 11-13, wherein the one or more attributes include one or more cost attributes, and wherein determining the ranking value for each of the plurality of candidate data sources comprises: determining a total cost based on the one or more cost attributes for each of the plurality of candidate data sources; and sorting the plurality of candidate data sources by the total cost.

(89) Example 15. The system of any of examples 11-14, wherein the attributes include one or more user-input value attributes, each of the one or more user-input value attributes including a user-defined weight, and wherein determining the ranking value for each of the plurality of candidate data sources comprises: sorting the plurality of candidate sources by the one or more user-input value attributes.

(90) Example 16. The system of any of examples 11-15, wherein the attributes include two or more user-input value attributes, and wherein determining the ranking value for each of the plurality of candidate data sources comprises: sorting the plurality of candidate sources by the user-input value attribute with a highest user-defined weight; and sorting the plurality of candidate sources by the user-input value attribute with a next highest user-defined weight.

(91) Example 17. The system of any of examples 11-16, wherein the output list includes a predetermined number of candidate data sources, wherein the predetermined number of candidate data sources included in the output list are candidate data sources with highest ranking values.

(92) Example 18. The system of any of examples 11-17, wherein the one or more attributes include one or more of: binary attributes; cost attributes; or value attributes.

(93) Example 19. The system of any of examples 11-18, the operations further comprising: prior to routing the data request to the first candidate data source, updating the data object in a format associated with the first candidate data source.

(94) Example 20. A non-transitory computer-readable medium storing instructions that, when executed by one or more processors, cause the one or more processors to perform operations comprising: receiving, from a user device, a user input including a data request associated with one or more data gaps, wherein the data request includes a data object including one or more entities and one or more attributes associated with each of the one or more entities; receiving an input list including a plurality of candidate data sources for the data request; determining, by an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; sorting, by the AI model, the plurality of candidate data sources by the plurality of ranking values; in response to receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources; in response to receiving, from the user device, a response to the output list: routing the data request over a network to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value.

Claims

1. A computer-implemented method comprising: receiving, by one or more processors and from a user device, a user input including a data request associated with one or more data gaps, wherein the data request includes a data object including one or more entities and one or more attributes associated with each of the one or more entities; receiving, by the one or more processors, an input list including a plurality of candidate data sources for the data request; determining, by the one or more processors and an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; sorting, by the one or more processors and the AI model, the plurality of candidate data sources by the plurality of ranking values; in response to receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources; and in response to receiving, by one or more processors and from the user device, a response to the output list: routing, by the one or more processors and over a network, the data request to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking, by the one or more processors, routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value.
2. The computer-implemented method of claim 1, wherein the one or more attributes include one or more binary attributes, and wherein determining the plurality of ranking values for the plurality of candidate data sources comprises: determining whether each of the plurality of candidate data sources includes an entry for each of the one or more binary attributes; and upon determining that at least one of the plurality of candidate data sources does not include an entry for each of the one or more binary attributes, filtering the at least one of the plurality of candidate data sources from the output list.
3. The computer-implemented method of claim 2, wherein determining the plurality of ranking values for the plurality of candidate data sources further comprises: upon determining that two or more of the plurality of candidate data sources include an entry for at least one of the one or more binary attributes, sorting the two or more of the plurality of candidate data sources by a total

number of entries for at least one of the one or more binary attributes.

4. The computer-implemented method of claim 1, wherein the one or more attributes include one or more cost attributes, and wherein determining the plurality of ranking values for the plurality of candidate data sources comprises: determining a total cost based on the one or more cost attributes for each of the plurality of candidate data sources; and sorting the plurality of candidate data sources by the total cost.

5. The computer-implemented method of claim 1, wherein the one or more attributes include one or more user-input value attributes, each of the one or more user-input value attributes including a user-defined weight, and wherein determining the plurality of ranking values for the plurality of candidate data sources comprises: sorting the plurality of candidate sources by the one or more user-input value attributes.

6. The computer-implemented method of claim 1, wherein the one or more attributes include two or more user-input value attributes, and wherein determining the plurality of ranking values for the plurality of candidate data sources comprises: sorting the plurality of candidate sources by a user-input value attribute of the two or more user-input value attributes with a highest user-defined weight; and sorting the plurality of candidate sources by a user-input value attribute of the two or more user-input value attributes with a next highest user-defined weight.

7. The computer-implemented method of claim 1, wherein the output list includes a predetermined number of the plurality of candidate data sources, wherein the predetermined number of the plurality of candidate data sources included in the output list are ones of the plurality of candidate data sources with highest ranking values.

8. The computer-implemented method of claim 1, wherein the AI model comprises a plurality of AI agents performing operations in parallel, each of the plurality of AI agents including a cognitive model.

9. The computer-implemented method of claim 1, wherein the one or more attributes include one or more of: binary attributes; cost attributes; or value attributes.

10. The computer-implemented method of claim 1, further comprising: prior to routing the data request to the first candidate data source, updating, by the one or more processors, the data object in a format associated with the first candidate data source.

11. A system comprising: memory configured to store instructions; and one or more processors configured to execute the instructions to perform operations comprising: receiving, from a user device, a user input including a data request associated with one or more data gaps, wherein the data request includes a data object including one or more entities and one or more attributes associated with each of the one or more entities; receiving an input list including a plurality of candidate data sources for the data request; determining, by an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; sorting, by the AI model, the plurality of candidate data sources by the plurality of ranking values; in response to receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources; and in response to receiving, from the user device, a response to the output list: routing the data request over a network to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value.

12. The system of claim 11, wherein the one or more attributes include one or more binary attributes, and wherein determining the plurality of ranking values for the plurality of candidate data sources comprises: determining whether each of the plurality of candidate data sources includes an entry for each of the one or more binary attributes; and upon determining that at least

one of the plurality of candidate data sources does not include an entry for each of the one or more binary attributes, filtering the at least one of the plurality of candidate data sources from the output list.

13. The system of claim 12, wherein determining the plurality of ranking values for the plurality of candidate data sources further comprises: upon determining that two or more of the plurality of candidate data sources include an entry for at least one of the one or more binary attributes, sorting the two or more of the plurality of candidate data sources by a total number of entries for at least one of the one or more binary attributes.

14. The system of claim 11, wherein the one or more attributes include one or more cost attributes, and wherein determining the plurality of ranking values for the plurality of candidate data sources comprises: determining a total cost based on the one or more cost attributes for each of the plurality of candidate data sources; and sorting the plurality of candidate data sources by the total cost.

15. The system of claim 11, wherein the one or more attributes include one or more user-input value attributes, each of the one or more user-input value attributes including a user-defined weight, and wherein determining the plurality of ranking values for the plurality of candidate data sources comprises: sorting the plurality of candidate sources by the one or more user-input value attributes.

16. The system of claim 11, wherein the one or more attributes include two or more user-input value attributes, and wherein determining the plurality of ranking values for the plurality of candidate data sources comprises: sorting the plurality of candidate sources by a user-input value attribute of the two or more user-input value attributes with a highest user-defined weight; and sorting the plurality of candidate sources by a user-input value attribute of the two or more user-input value attributes with a next highest user-defined weight.

17. The system of claim 11, wherein the output list includes a predetermined number of the plurality of candidate data sources, wherein the predetermined number of the plurality of candidate data sources included in the output list are ones of the plurality of candidate data sources with highest ranking values.

18. The system of claim 11, wherein the one or more attributes include one or more of: binary attributes; cost attributes; or value attributes.

19. The system of claim 11, the operations further comprising: prior to routing the data request to the first candidate data source, updating the data object in a format associated with the first candidate data source.

20. At least one non-transitory computer-readable medium storing instructions that, when executed by one or more processors, cause the one or more processors to perform operations comprising: receiving, from a user device, a user input including a data request associated with one or more data gaps, wherein the data request includes a data object including one or more entities and one or more attributes associated with each of the one or more entities; receiving an input list including a plurality of candidate data sources for the data request; determining, by an artificial intelligence (AI) model, a plurality of ranking values for the plurality of candidate data sources respectively based on the one or more attributes, each of the plurality of ranking values indicative of a likelihood of filling the one or more data gaps associated with the data request; sorting, by the AI model, the plurality of candidate data sources by the plurality of ranking values; in response to receiving the data request, transmitting, by the one or more processors and to the user device, an output list that includes the sorted plurality of candidate data sources; and in response to receiving, from the user device, a response to the output list: routing the data request over a network to a first candidate data source of the plurality of candidate data sources based on a first ranking value of the plurality of ranking values; and blocking routing of the data request over the network to a second candidate data source of the plurality of candidate data sources based on a second ranking value of the plurality of ranking values, wherein the first ranking value is higher than the second ranking value.

