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(54) **CONVERSATIONAL PROGRAMMING INTERFACE**

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G06F 17/28	(2006.01)
G10L 15/19	(2013.01)
G06F 17/24	(2006.01)

(52) **U.S. Cl.**
CPC ***G10L 15/22*** (2013.01); ***G06F 17/24*** (2013.01); ***G06F 17/289*** (2013.01); ***G06F 17/2809*** (2013.01); ***G06F 17/2881*** (2013.01); ***G10L 15/19*** (2013.01); *G10L 2015/223* (2013.01)

(58) **Field of Classification Search**
CPC . G10L 15/22; G10L 17/2809; G10L 17/2881; G10L 17/28; G10L 17/289; G06F 17/2809; G06F 17/2881; G06F 17/28; G06F 17/289
See application file for complete search history.

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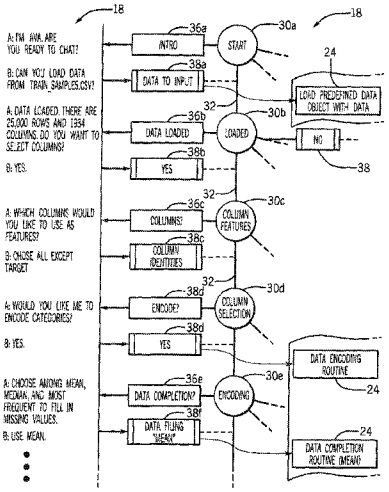
(57) **ABSTRACT**

Domain specific programming is facilitated through the use of a conversational interface using natural language commands from the user and natural language cues to the user. The natural language conversation provides the actual program and thus can be saved and edited for future use.

17 Claims, 3 Drawing Sheets



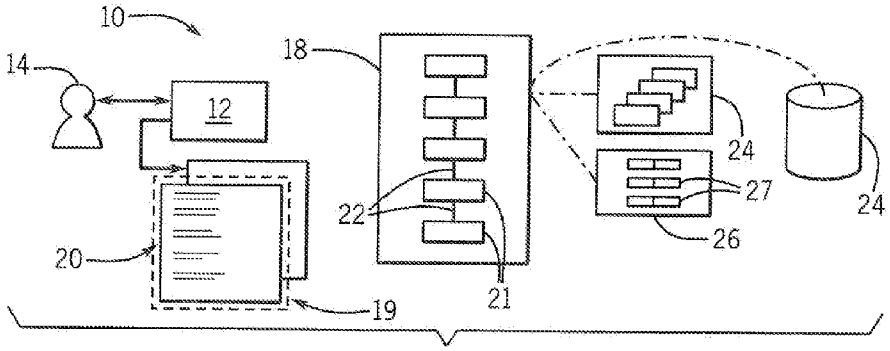


FIG. 1

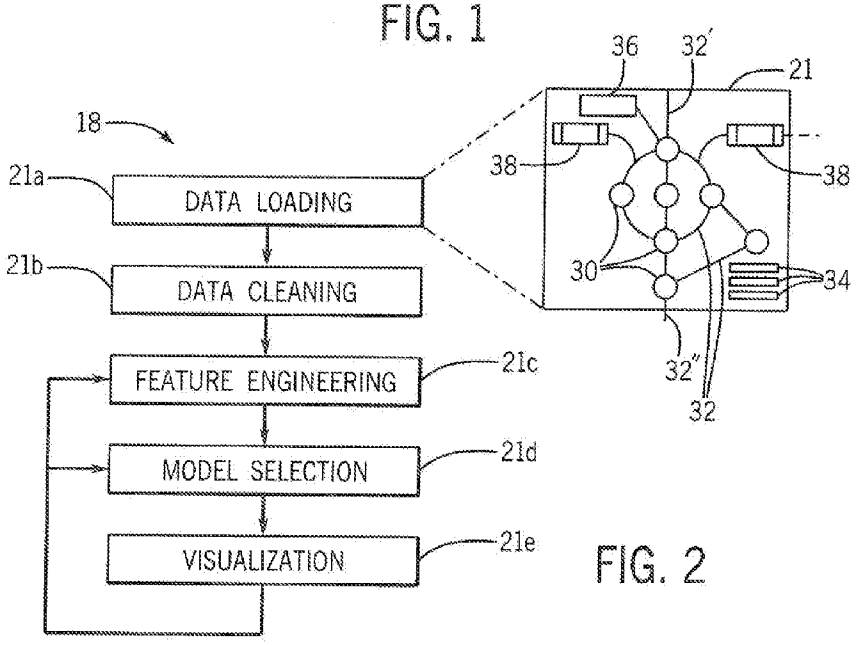


FIG. 2

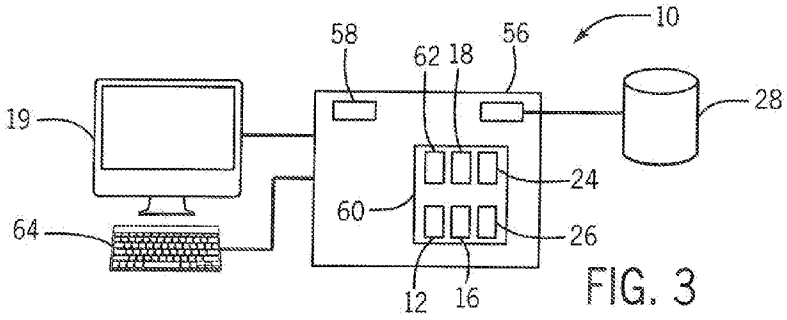


FIG. 3

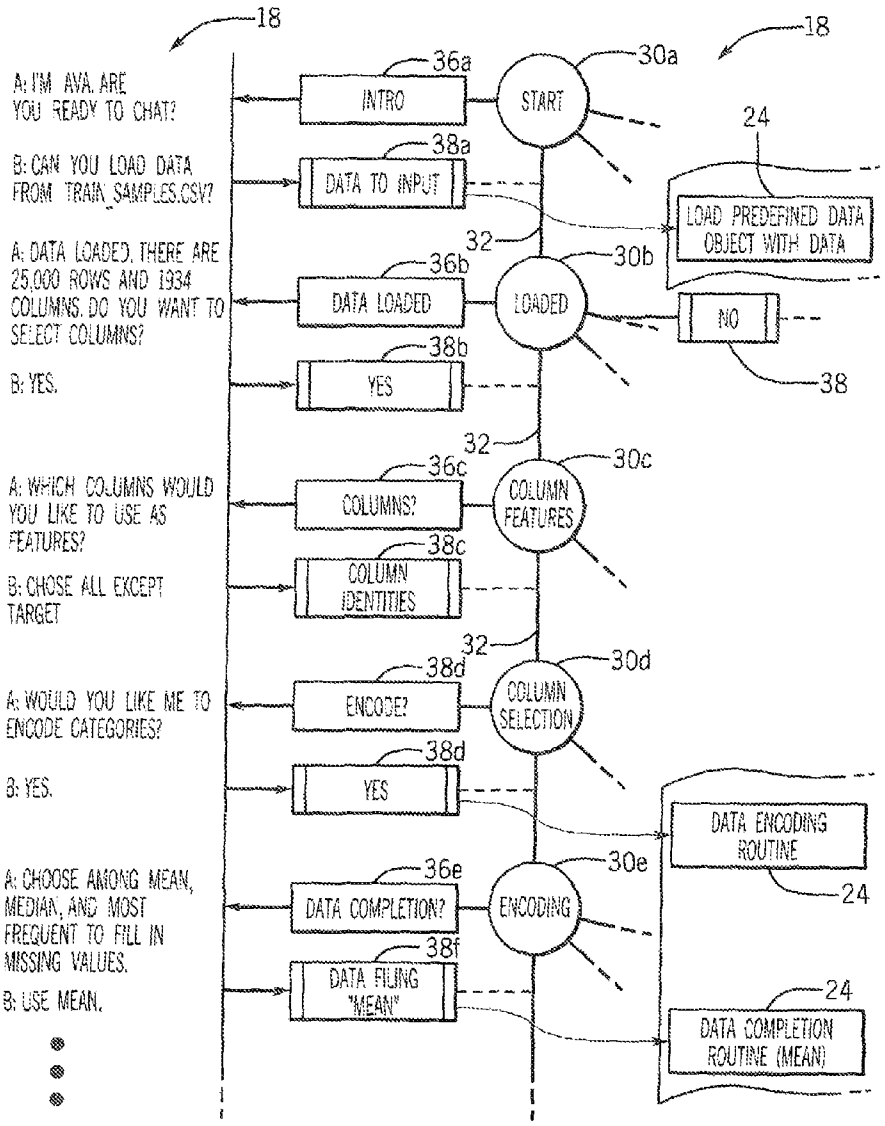

18
18
A: I'M AVA. ARE YOU READY TO CHAT?
36a
INTRO
START
30a
24
B: CAN YOU LOAD DATA FROM TRAIN_SAMPLES.CSV?
38a
DATA TO INPUT
LOAD PREDEFINED DATA OBJECT WITH DATA
32
A: DATA LOADED. THERE ARE 25,000 ROWS AND 1934 COLUMNS. DO YOU WANT TO SELECT COLUMNS?
36b
DATA LOADED
LOADED
30b
NO
38
B: YES.
38b
YES
32
A: WHICH COLUMNS WOULD YOU LIKE TO USE AS FEATURES?
36c
COLUMNS?
COLUMN FEATURES
30c
B: CHOSE ALL EXCEPT TARGET
38c
COLUMN IDENTITIES
32
A: WOULD YOU LIKE ME TO ENCODE CATEGORIES?
38d
ENCODE?
COLUMN SELECTION
30d
B: YES.
38d
YES
DATA ENCODING ROUTINE
24
A: CHOOSE AMONG MEAN, MEDIAN, AND MOST FREQUENT TO FILL IN MISSING VALUES.
36e
DATA COMPLETION?
ENCODING
30e
B: USE MEAN.
38f
DATA FILING "MEAN"
24
DATA COMPLETION ROUTINE (MEAN)

FIG. 4

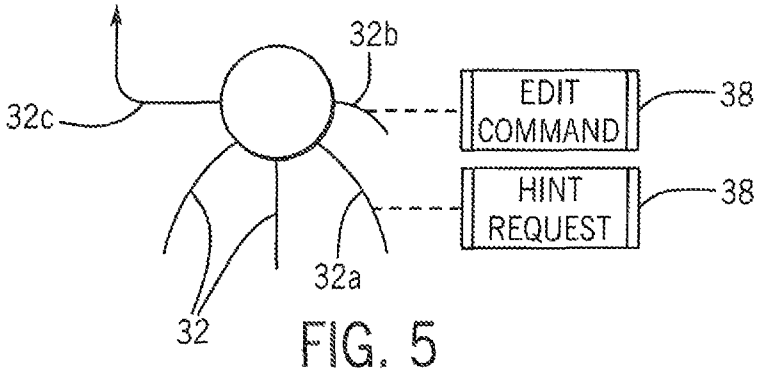


FIG. 5

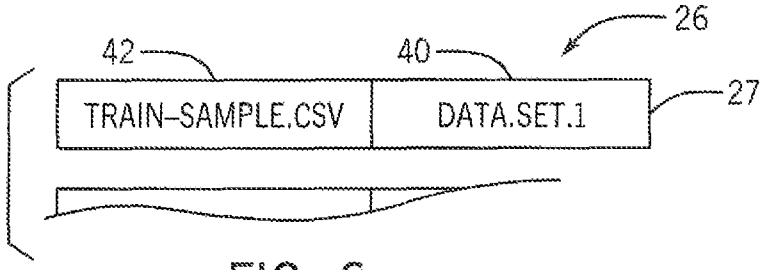


FIG. 6

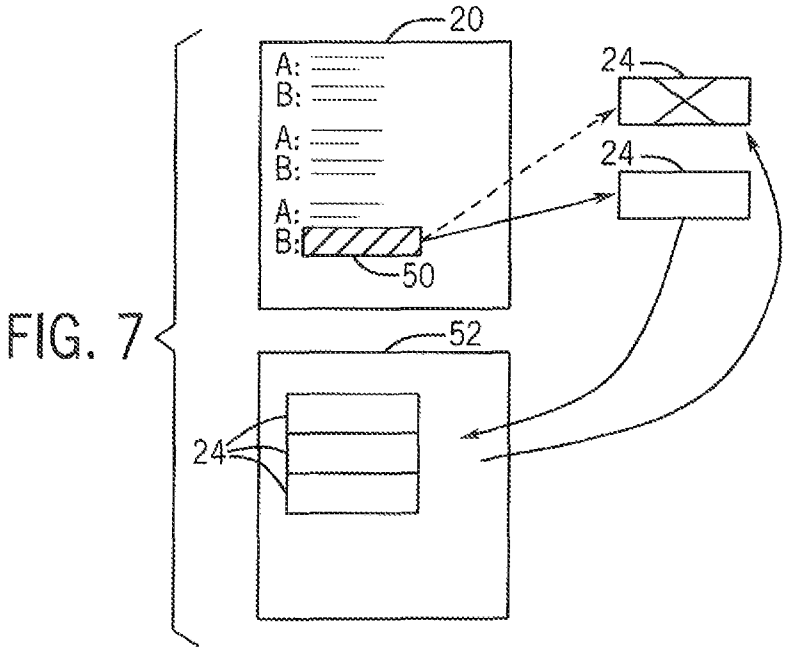


FIG. 7

CONVERSATIONAL PROGRAMMING INTERFACE

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

This invention was made with government support under IIS0963993 and IIS1250886 awarded by the National Science Foundation, and AI17924 awarded by the National Institutes of Health. The government has certain rights in the invention.

CROSS REFERENCE TO RELATED APPLICATION

N/A

BACKGROUND OF THE INVENTION

The present invention relates to a system and method for programming electronic computers and in particular to a programming method that captures a program in natural language to improve the accessibility of sophisticated computational tools to occasional users.

Computers have provided data scientists with a wide array of tools and processes, for example, for the analysis of data particularly as captured in large databases. Making effective use of these tools, however, can be difficult, typically requiring that the domain specialist (having knowledge of the data) work with a data scientist (having knowledge of the computerized tools) to apply the tools to a particular analysis problem. This division of the task among two individuals generally increases the time and cost of using otherwise powerful computerized tools, creates a risk of misinterpretation and translation errors in the communication between the individuals, and makes experimentation and iteration of the type often required in data analysis cumbersome.

The problem of making sophisticated computerized tools more accessible is addressed in part by the creation of special high-level languages that invoke these computerized tools, these special, high-level languages intended to be easy to use by domain specialists by providing interfaces (such as graphical interfaces or the like) that help construct programs to use the computerized tools, or by attempting to partially or fully automate the programming process.

A fundamental problem with simplified programming languages is the relatively low tolerance occasional users have for learning specialized programming languages which necessarily mirror the complexity of the tools that they invoke. To the extent that such specialized programming languages are well adapted for a particular problem, for example, automating steps to reduce the complexity of the problem, such languages may lose flexibility by being over-adapted to a narrow set of problems, thereby being unsuitable to the domain specialist having a variety of data analysis problems.

SUMMARY OF THE INVENTION

The present invention provides a programming language that adopts a conversational paradigm of constrained natural language. By using natural language, for example, implemented by a chat-bot or the like, special commands and syntaxes can be avoided. Importantly, the conversation allows the introduction of conversational style hints and directions to the user, preventing the user from having to commit a wide variety of commands and options to memory.

To the extent that users may be assumed to have natural facility with real language, a natural language conversation requires very little learning overhead. In addition, the natural language conversation when recorded provides a simple and easily accessible "source code" capturing a programming solution that may be reused and modified.

Specifically, in one embodiment, the invention provides a computerized user interface for data analysis comprising an electronic computer having a processor, an electronic memory communicating with the processor and holding a program-generating program, a set of multi-instruction program components and a user interface communicating with the processor. The processor executes the program to generate a conversation comprised of: (i) natural language phrases input by a user using the user interface and designating one or more data sets for analysis and one or more analysis tools to be used in the analysis; and (ii) natural language phrases output by the computer using the user interface in response to the natural language phrases input by the user and providing the user with guidance for additional natural language phrases input by the user. This conversation may be recorded and executed, the execution mapping the natural language phrases input by the user to corresponding multi-instruction program components to create a data analysis program implementing analysis of the one or more analysis tools on the data set. Execution of this data analysis program outputs analysis to the user interface.

It is thus a feature of at least one embodiment of the invention to substantially increase the accessibility of domain specific computer tools to occasional users by constraining the interface to natural language conversation providing a two-way communication flow that prevents the need for the user to commit to memory details of the tool operations.

The program-generating program may further display the conversation contemporaneously with generation of the program.

It is thus a feature of at least one embodiment of the invention to provide a running record of the conversation both for reference by the user during generation of the program and a guide to future users of the program where the conversation provides context to the program logic analogous to "comments" used in standard computer source code.

The program-generating program may further operate to: (d) store and recall the conversation; and (e) edit the recalled conversation before repeating step (c).

It is thus a feature of at least one embodiment of the invention to provide a programming interface generating a conversation that is in fact executable code subject to editing and reuse. In this way the accessibility of the computer tools is increased for both first time and subsequent use.

The recalled conversation may be displayed and the editing guided by identifying portions of the conversation on the display and editing those portions through the addition of new natural language phrases input by the user.

It is thus a feature of at least one embodiment of the invention to permit editing of the program in the natural language domain, preserving the conversational nature of the program in a way that is consistent with the goal of increased accessibility of computer tools.

The editing of the recalled conversation may permit removal of natural language phrases and the addition of natural language phrases at a variety of points within the conversation, and the removal of a natural language phrase from the conversation may cause a removal of a corresponding multi-instruction program component during execution

of the conversation, and the addition of a natural language phrase to the conversation may cause an addition of a corresponding multi-instruction program component during the execution.

It is thus a feature of at least one embodiment of the invention to provide a simple method of ensuring consistency (executability) of the program during natural language editing.

The program-generating program may further include a predefined multi-state template designating steps for a workflow, the multi-state template defining states associated with predefined possible natural language phrases output by the computer and state transitions associated with predefined possible natural language phrases input by the user.

It is thus a feature of at least one embodiment of the invention to provide a simple method of converting computerized tools to the natural language interface through the use of an overarching multi-state template to which natural language cues and grammars may be attached.

The natural language phrases output by the computer may provide hints with respect to possible state transitions of the predefined multi-state template for a given current state of the multi-state template.

It is thus a feature of at least one embodiment of the invention to provide natural language support to the user that is a dynamic function of the current state in the multi-state template, that is, to provide context-sensitive support to the user.

The predefined possible natural language phrases input by the user may each be associated with a corresponding multi-instruction program component.

It is thus a feature of at least one embodiment of the invention to provide a simple method of converting natural language phrases into executable programs by providing a simple mapping between natural language phrases and program fragments.

The multi-state template may be composed of modules each providing multiple states and selected from the group consisting of states related to: data loading, data cleaning, data analysis, model selection, and visualization of analysis.

It is thus a feature of at least one embodiment of the invention to provide a simple method of increasing the accessibility of data analysis tools to domain experts.

The modules may provide for standardized interfaces so that a given module of the multi-state template can be replaced by a different module.

It is thus a feature of at least one embodiment of the invention to simplify the updating and expansion of the tools accessed by the present invention.

These particular objects and advantages may apply to only some embodiments falling within the claims and thus do not define the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified block diagram of the interface of the present invention employing a chat-bot driven by a multi-state template linked to a set of code fragments and standardize data objects producing a conversation that may be displayed and recorded;

FIG. **2** is an expanded depiction of the multi-state template showing primary states for a data analysis template each including sub-stages associated with natural language cues and grammars;

FIG. **3** is a block diagram of an electronic computer suitable for implementation of the present invention;

FIG. **4** is a flow chart of an example portion of a conversation as implemented by the present invention providing access to sophisticated data analysis tools;

FIG. **5** is a depiction of an example sub-state multi-state template showing common state transitions for providing a hint to the user or accepting edit commands;

FIG. **6** is a detailed depiction of standardized data objects linked to aliases used by a domain specialist; and

FIG. **7** is an example display of a conversation showing a highlighting of conversational elements for editing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. **1**, a conversational programming interface **10** of the present invention may provide for a chat-bot **12** for receiving and interpreting natural language statements from a domain expert **14** and for outputting natural language statements to the domain expert **14**. This communication may be implemented in a variety of means, for example, through speech recognition and text synthesis or by means of a combination of a keyboard and graphic display as will be discussed in detail below.

As is generally understood in the art, a chat-bot **12** is a program that provides the ability to communicate through controlled natural language (CNL) statements, being a constrained set of syntactically correct sentences understandable to native speakers of a language. Generally, these statements are a subset of possible statements in the language and may be analyzed by the chat-bot **12** according to an internally defined grammar to extract underlining meaning. The chat-bot **12** may also output syntactically correct natural language statements also being part of a controlled natural language set. In one embodiment, the controlled natural language may consist of sentence structures having the following form: <ACTION VERB><NOUN> <PREDICATE>. A chat-bot **12** suitable for this purpose is described in R. Schwitter, Controlled natural languages for knowledge representation, in Proceedings of the International Conference on Computational Linguistics, pp. 1113-1121, 2010, hereby incorporated by reference.

The natural language statements received by the chat-bot **12** from the domain expert **14** may be recorded in a file **16** and simultaneously displayed on a display **19** together with the natural language statements from the chat-bot **12** to the domain expert **14**, the latter interleaved with the former in a human readable conversational conversation **20** having the visual form of a standard natural language dialogue, for example, with each statement attributed to a "speaker" being either the chat-bet **12** or the domain expert **14**.

Alternatively, the natural language statements received by the chat-bet **12** from the domain expert **14** may be preprocessed for content by the chat-bet **12** and then re-formed into an interpreted natural language statement having identical meaning to the statement received by the chat-bet **12**. This latter interpreted natural language statement may then be displayed and recorded so as to better reveal the understanding of the chat-bet **12**.

Generally the chat-bot **12**, as noted, may work with a constrained grammar and cue-vocabulary which will be provided by a multi-state template **18**. The multi-state template **18** may include a set of stages **21** defining particular steps in a domain specific problem such as data analysis, and operates to provide natural language cues to the domain expert **14** at each stage. The stages **21** are linked stage transitions **22** in the manner of a cyclic graph, the stage transitions **22** each associated with rules determining when

the stage transitions **22** are invoked and each linked to a grammar describing natural language statements that must be received by the chat-bet **12** to satisfy the rule of the stage transition **22**. An example multi-state template **18** will be described below.

The multi-state template **18** may communicate with a library of code fragments **24** representing methods or tasks that can be implemented for data analysis of a type desired by the domain expert **14**. Generally the code fragments **24** will represent common tools or tasks used in data analysis and may be written in a variety of different languages or scripts as desired. Accordingly, the code fragments **24** may make use of the most convenient language for the given task including general purpose programming language like Python, R or Scala, and may use pre-existing libraries like Scikit-learn, Caret or Spark.

The code fragments **24** may operate on predefined standardized variables so that they may be compatible and seamlessly communicate data. These predefined standardized variables may be in the form of data objects **27** of a data object table **26** and allow, for example, for the output of one code fragment **24** to provide data that can be then used as inputs to other code fragments **24** without further programming.

As will be discussed below, these data objects **27** of data object table **26** will be linked to specified user data identified by the domain expert **14** during use of the conversational programming interface **10**. The user-specified data may be held in a user data repository **28**. In operation, the multi-state template **18** will generally invoke a set of code fragments **24** to operate on the data objects **27** according to the conversation **20**, the data objects previously linked to specific user data in the user data repository **28**.

Referring now to FIG. **2**, an example set of stages **21***a-e* suitable for data analysis may include: a stage **21***a* of data loading, where data to be analyzed by the domain expert **14** is identified in the data repository **28**; a stage **21***b* of data cleaning, where clearly erroneous data and missing data is corrected or completed; a stage **21***c* of feature engineering, for example, where types of nonnumeric data are encoded or partitioned for numeric analysis; a stage **21***d* of model selection wherein an analysis model is selected possibly with feedback to the user (e.g., using ROC curves or R^2 values) with respect to precision and recall; and a stage **21***e* of visualization where the analysis is visualized, for example, in a chart type (e.g., histograms, scatterplots, etc.) selected by the user. Generally the multi-state template **18** contemplates that the analysis will be iterative with stages **21***c* or **21***d* being repeated one or more times with modifications after visualization of stage **21***e*.

Each of the stages **21** may include multiple sub-stages **30** interconnected by state transitions **32**. In a simple case, the sub-stages **30** of the stages **21** may have a single entry point state transition **32'** and exit point state transition **32"** allowing each of the stages **21** to be easily integrated with other stages **21** through interconnection of a single state transition. Each of the stages **21** may also identify a set of input and output variables **34** used by the stage **21** to facilitate the interconnection of stage **21**, or swapping of one stage **21** with other similar stages **21**, for example, when different data cleaning stages **21** might be used. The set of input and output variables **34** may be used to make sure the stages **21** are compatible, that is, finding input variables in one of the earlier stages **21** and providing output variables that are used by one of the later stages **21**. The set of input and output variables **34** may also identify data types for compatibility, for example, a data loading stage **21** may identify a standard variable being a target database in a particular format, for example, comma separated values (CSV). Object wrappers for the data objects **27** may provide for basic conversion between different data types.

Each sub-stage **30** of each stage **21** of the multi-state template **18** may be associated with a natural language output cue **36** providing information to the domain expert **14** through the chat-bot **12** when that sub-stage **30** is encountered. Similarly, each state transition **32** may be associated with a natural language input grammar **38** describing valid natural language inputs received from the domain expert **14** through the chat-bot **12** such as will invoke the state transition **32**. Generally, the natural language input grammar **38** will describe the content of a received statement from the domain expert **14** rather than an exact statement (through the interpretive abilities of the chat-bot **12**) so that the state transition **32** may be invoked by a variety of different natural language statements having identical content.

Referring now also to FIG. **5**, normally the natural language output cue **36** of each sub-stage **30** will provide the user with a current context of the data processing task; however, desirably each of the sub-stages **30** will also provide at least one state transition **32***a* that can provide a state-appropriate hint to the domain expert **14** on request, for example, triggered by a question such as "what are my options here?" The hints associated with each sub-stage **30** may also or alternatively provide an indication of the types of state transitions **32** that are available. The invention contemplates that one natural language input grammar **38** may invoke a listing of all possible state transition types, for example, like a "list" command.

In addition each sub-stage **30** may include state transition **32***b* allowing for editing of the conversation **20**, for example, replacement or modification of previous natural language statements by the domain expert **14** previously enrolled in the conversation **20**. These editing commands are not entered into the conversation **20** but instead operate to modify the conversation **20**. The invention contemplates that some of the state transitions **32***c* may provide for a looping back to previous sub-stages **30**, for example, when iteration or revision is desired.

Both the natural language output cues **36** and natural language input grammars **38** may include placeholders for receiving or outputting user-designated variable names. These user designated variable names will be linked to the standardized data objects **27** which will hold the underlying data. Referring also to FIG. **6**, in this regard, the data objects **27** may thus provide both a standardized data object name **40** used by the program fragments **24** linked to an alias **42** used by the domain expert **14** and in the placeholders of the natural language conversation **20**. Thus, for example, the natural language input grammar **38** may have a placeholder to receive a name of a file to be processed from data repository **28** designated "train_sample.csv" being a user supplied name. This user-supplied name is then associated with a standard data object for processing "data_set_1" that will be used by the code fragments **24**. The chat-bot **12** may extract the user-supplied alias **42** from natural language statements and link them to the standardized data object name **40** implicated by the current sub-stage **30**. At that point, the alias **42** will be used in all communications with the domain expert **14**. During the loading of data to be described below, the data associated with the user supply alias **42** will be loaded into the a standardized data object **27** associated with a data object name **40**.

Referring now to FIG. **4**, an example generation of a conversation **20** of the type provided by the present inven-

tion will now be described. In this process, the conversational programming interface **10** initializes at a first stage **21** and its first sub-stage **30**, in this case indicated by sub-stage **30***a*, is a starting state. The starting sub-stage **30***a* will be associated with a natural language output cue **36***a*, for example, introducing the program, for example, with a statement such as:

"Hello! I am Ava, the data science chat-bot. I'm ready to chat."

This output is communicated to the domain expert **14** and recorded in the file **16** as part of the generated conversational source code as well as displayed on display **19**. The chat-bot **12** then monitors the natural language input grammars **38** of all state transitions from sub-stage **30***a*, for example, looking for a natural language input grammar **38***a* indicating an identification of a data file to be processed, for example, per the natural language statement:

"Can you load data from train_sample.csv?"

This matching is done in a content domain and does not require an exact phrasing as shown above. This statement like all statements from the chat-bot and to the chat-bot is recorded in file **16** and displayed in conversation **20** on display **19**.

In response to a matching of the natural language input grammar **38**, the chat-bot **12** may execute a code fragment **24** that will undertake a loading of the indicated data. At this time the standard input variable used for the data being processed "data_set_1" is associated with the user supplied alias of "train_sample.csv" and the code fragment **24**, and subsequent code fragments **24** may make use of the standard input variable in dealing with this data set. When the code fragment **24** is complete, state transition **32***a* from sub-stage **30***a* to sub-stage **30***b* may be invoked.

At sub-stage **30***b*, the natural language output cue **36***b* indicating that the data was successfully loaded is provided to the domain expert **14** to preserve context for the process, for example, with the statement:

"Data loaded successfully. There are 25,000 rows in 1934 columns in your data. Do you want to select columns as features?"

This natural language output cue **36***b* both confirms the previous operation and provides the domain expert **14** with an option appropriate to the sub-stage **30***b*.

The chat-bot **12** then monitors responses associated with different state transitions from sub-stage **30***b*, for example, receiving a "yes" response matching grammar **38***b* causing a transition to sub-stage **30***c*. For this particular matching grammar **38***b* no fragment **24** need be invoked.

At sub-stage **30***c*, natural language output cue **36***c* requests an identification of the columns to be selected in accordance with the response of the previous state transition, for example, stating:

"Which columns would you like to use as features?"

The chat-bot **12** again monitors the natural language input grammars **38** leading from sub-stage **30***c* (possibly iteratively) receiving the user-defined column names in placeholders and matching those user-defined column names as aliases to the column headers of the loaded file. Each match identifies the match columns to standard data object names **40** in data object table **26** for use by any of the program fragments **24**. This use of standard data object names **40** allows the later program fragments **24** to be prewritten for use with the standard variables and yet to be responsive to new variable names introduced by the domain expert **14**. These steps may be implemented by general program instructions incorporated into the conversational programming interface **10**.

In this case, the chat-bot **12** may receive a command from the domain expert **14** of: "Choose all, except target" matching natural language input grammar **38***c*, allowing all of the columns except for the target to be marked for use by later program fragments.

Satisfaction of the natural language input grammar **38***c* causes state transition **32** from sub-stage **30***c* to sub-stage **30***d* to occur invoking the natural language output cue **36***d* of:

"Would you like me to encode categorical features?"

This question is related to a step of feature engineering before analysis. A response of"yes" (matching natural language input grammar **38***d*) causes a state transition to sub-stage **30***e* and an invocation of the code fragment **24** to perform the necessary encoding modifying the data appropriately with reference to the standardized variables.

At sub-stage **30***e*, a natural language output cue **36** asks the domain expert **14** about how to manage missing values, for example, to fill in those missing values with averages or the like with a statement of:

"Choose among mean, median, and most frequent to fill in missing values".

The sub-stage **30***e* in this case will have multiple state transitions **32** leading from it to different options associated with filling in missing data, one of which will be selected depending on the response received from the domain expert **14**. For example, the natural language statement of: "Use mean" may match a natural language input grammar **38***f* associated with the program fragment **24** providing this function.

It will generally be appreciated that multi-state template **18** may be preprepared and then used for many different data analysis problems having the same stages **21**. To the extent that the stages **21** of the multi-state template **18** are modular (having single entry and exit points and predefined variables), it is relatively easy to generate new multi-state templates **18** by starting with previously generated multi-state templates **18** and changing the stages **21**. In one embodiment, the natural language input grammars **38** and natural language output cues **36** related to each code fragment **24** may be incorporated into the code fragments **24** and compiled into the multi-state template **18**. In this way the code fragments **24** may carry with them hints and the ability to make recommendations to the domain expert **14** with respect to how to treat or handle the data that they are associated with. Otherwise, a variety of analysis frameworks may be easily implemented in the construction of the multi-state templates **18** simply by identifying or generating the necessary cues **36**, grammars **38** and code fragments **24**.

Referring now to FIGS. **1** and **7**, at the conclusion of this process of FIG. **4**, a complete record of the process and the necessary data analysis is captured in the conversation **20** together with the desired output, for example, in the form of charts or the like (displayed graphically in line with the conversation in the manner of a workbook). The source code is naturally "commented" to the extent that it provides natural language explanation of each of the steps of data analysis and the outputs.

Importantly, this conversation **20** can be saved by saving file **16** and re-executed at a later date on the same named data, for example, which may have changed. More typically, prior to such reexecution, portions of the conversation **20** may be edited, for example, to change the source data files from repository **28** but any feature of the conversation **20** may be changed by invoking editing commands that may be implemented also through natural language or more typically through normal input devices such as keyboards and

the like. In this process, any given user input **50** in the conversation **20** may be highlighted and may be replaced, for example, with a natural language input. The program moves to the necessary sub-stage **30** and uses the chat-bot to interpret the new natural language instruction to match it to a given fragment **24** or a fragment **24** as may be necessary or to otherwise change the data object table **26**. All subsequent fragments **24** (as previously defined by the conversation **20**) are then re-executed.

The invention contemplates that the code fragments **24** as invoked by the conversation **20** may be assembled together as the conversation **20** is constructed, and these code fragments **24** displayed as a program view **52** allowing the expert to simultaneously view the conversation **20** and the corresponding underlining code of the multiple code fragments **24** for best understanding of the process being performed and even to provide editing through the program view **52**.

When the user saves the conversation **20**, options may exist to remove iterations, for example, experiments with possible ways of analyzing the data that were not ultimately used so as to provide a template for future use that has been pruned of unnecessary side paths.

It will be appreciated that the code fragments **24** may make use of existing tools or programs for data analysis providing the data to those tools in command line form to receive responses without the need for necessary reconstructing or writing the code of the code fragments **24**.

Referring now to FIG. **3**, the conversational programming interface **10** may be implemented on standard desktop computer **56** having one or more processors **58** communicating with a memory **60** holding a stored program generating program **62** implementing the above described conversational programming interface **10** together with one or more multi-state templates **18**, code fragments **24**, a data object table **26**, one or more conversational storage file **16**, and a chat-bot **12**. The computer **56** may communicate with a display **19**, for example, a graphic display and a keyboard **64** and may connect to the data repository **28** holding the user data.

Certain terminology is used herein for purposes of reference only, and thus is not intended to be limiting. For example, terms such as "upper", "lower", "above", and "below" refer to directions in the drawings to which reference is made. Terms such as "front", "back", "rear", "bottom" and "side", describe the orientation of portions of the component within a consistent but arbitrary frame of reference which is made clear by reference to the text and the associated drawings describing the component under discussion. Such terminology may include the words specifically mentioned above, derivatives thereof, and words of similar import. Similarly, the terms "first", "second" and other such numerical terms referring to structures do not imply a sequence or order unless clearly indicated by the context.

When introducing elements or features of the present disclosure and the exemplary embodiments, the articles "a", "an", "the" and "said" are intended to mean that there are one or more of such elements or features. The terms "comprising", "including" and "having" are intended to be inclusive and mean that there may be additional elements or features other than those specifically noted. It is further to be understood that the method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

References to "a microprocessor" and "a processor" or "the microprocessor" and "the processor," can be understood to include one or more microprocessors that can communicate in a stand-alone and/or a distributed environment(s), and can thus be configured to communicate via wired or wireless communications with other processors, where such one or more processor can be configured to operate on one or more processor-controlled devices that can be similar or different devices. Furthermore, references to memory, unless otherwise specified, can include one or more processor-readable and accessible memory elements and/or components that can be internal to the processor-controlled device, external to the processor-controlled device, and can be accessed via a wired or wireless network.

It is specifically intended that the present invention not be limited to the embodiments and illustrations contained herein and the claims should be understood to include modified forms of those embodiments including portions of the embodiments and combinations of elements of different embodiments as come within the scope of the following claims. All of the publications described herein, including patents and non-patent publications, are hereby incorporated herein by reference in their entireties.

What we claim is:

1. A computerized user interface for data analysis comprising an electronic computer including:

a processor;

electronic memory communicating with the processor and holding a program-generating program and a set of multi-instruction program components; and

a user interface communicating with the processor;

wherein the processor executes the program-generating program to:

(a) generate a conversation comprised of:

(i) natural language phrases input by a user using the user interface and designating a data set for analysis and one or more analysis tools to be used in the analysis; and

(ii) natural language phrases output by the computer using the user interface in response to the natural language phrases input by the user and providing the user with guidance for additional natural language phrases input by the user;

(b) record the conversation; and

(c) execute the conversation by mapping the natural language phrases input by the user and the additional natural language phrases input by the user to corresponding multi-instruction program components to create a data analysis program implementing analysis of the one or more analysis tools on the data set; and executing the data analysis program to output that analysis to the user interface.

2. The computerized user interface of claim **1** wherein the program-generating program further displays the conversation contemporaneously with generation of the data analysis program.

3. The computerized user interface of claim **2** wherein the processor further executes the program-generating program to perform the steps of:

(d) storing and recall the conversation; and

(e) editing the recalled conversation before repeating step (c).

4. The computerized user interface of claim **3** wherein the recalled conversation is displayed and the editing is guided by identifying portions of the conversation on the display

and editing those portions through an addition of new natural language phrases input by the user.

5. The computerized user interface for data analysis of claim **4** wherein the editing of the recalled conversation allows removal of existing natural language phrases and an addition of further natural language phrases at a variety of points within the conversation and wherein the removal of a given existing natural language phrase from the conversation causes a removal of a corresponding multi-instruction program component during execution of the conversation and wherein the addition of a given further natural language phrase to the conversation causes an addition of a corresponding multi-instruction program component during the execution of the conversation.

6. The computerized user interface of claim **1** wherein the program-generating program further executes to include a step of receiving commands from the user to edit the data analysis program before executing the data analysis program at step (c).

7. The computerized user interface of claim **1** wherein the program-generating program further includes a predefined multi-state template designating steps for a workflow, the multi-state template defining states associated with predefined possible natural language phrases output by the computer and state transitions associated with predefined possible natural language phrases input by the user.

8. The computerized user interface of claim **7** wherein the natural language phrases output by the computer provide hints with respect to possible state transitions of the predefined multi-state template for a given current state of the multi-state template.

9. The computerized user interface of claim **7** wherein the predefined possible natural language phrases input by the user are each associated with a corresponding multi-instruction program component.

10. The computerized user interface of claim **7** wherein the multi-state template is composed of modules each providing multiple states and selected from the group consisting of states related to: data loading, data cleaning, data analysis, model selection, and visualization of analysis.

11. The computerized interface of claim **10** wherein the modules provide for standardized interfaces so that a given module of the multi-state template can be replaced by a different module.

12. The computerized user interface for data analysis of claim **1** wherein the natural language phrases input the u ad the natural language phrases output by the computer conform to standard spoken language grammar and syntax.

13. The computerized user interface for data analysis of claim **1** wherein the multi-instruction program components are human readable instructions and a non-natural language computer language.

14. A method of computerized data analysis employing an electronic computer having a processor; and electronic memory communicating with the processor and holding a program-generating program and a set of multi-instruction program components; and a user interface communicating with the processor, the method comprising:

(a) generating a conversation comprised of:

(i) natural language phrases input by a user using the user interface and designating one or more data sets for analysis and one or more analysis tools to be used in the analysis; and

(ii) natural language phrases output by the computer using the user interface in response to the natural language phrases input by the user and providing the user with guidance for additional natural language phrases input by the user,

(b) recording the conversation; and

(c) executing the conversation by mapping the natural language phrases input by the user and the additional natural language phrases input by the user to corresponding multi-instruction program components to create a data analysis program implementing analysis of the one or more analysis tools on the data set; and executing the data analysis program to output that analysis to the user interface.

15. The method of claim **14** including the step of displaying the conversation contemporaneously with generation of the data analysis program.

16. The method of claim **15** including the step of:

(d) storing and recall the conversation; and

(e) edit the recalling conversation before repeating step (c).

17. The method of claim **16** wherein the recalled conversation is displayed and the editing is guided by identifying portions of the conversation on the display and editing those portions through an addition of new natural language phrases input by the user.

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