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(54) Title: GENERATING A DATA VISUALIZATION

(57) Abstract: Generating a data visualization, including: receiving an input data set comprising a plurality of data objects; receiving a first and second visualization type selections; generating a first and second visualization modules using the plurality of data objects and the first and second visualization type selections; receiving a selected connector option from a plurality of selectable connector options; and generating a dynamic visualization by connecting the first visualization module and the second visualization module using the selected connector option.

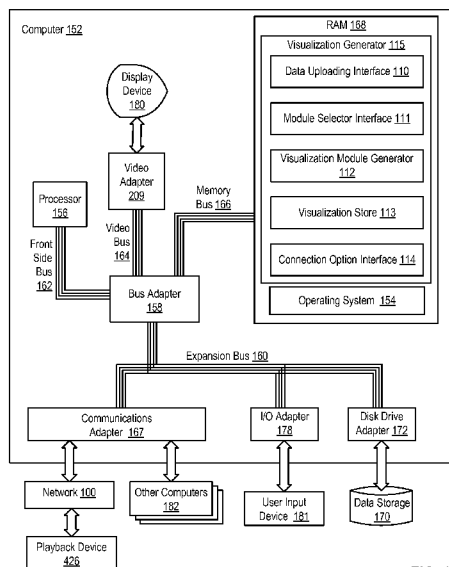


FIG. 1

GENERATING A DATA VISUALIZATION

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

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10 Government has certain rights in the invention.

BACKGROUND OF THE INVENTION

Field of the Invention

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The field of the invention is data processing, or, more specifically, methods, apparatuses, and products for generating a data visualization.

Description Of Related Art

As computing power increases, and more research fields generate increasing volumes of data, the need to analyze and visualize that data has also increased. In some data visualizations, the visualization is limited to a three-dimensional core with a few options for additional dimensions specified by graphic elements (e.g. color, node size, edge width). As the size and complexity of data sets increase, the corresponding visualization need must also account for data sets of not only large dimension, but also myriad data types.

SUMMARY OF THE INVENTION

Methods, apparatuses, and products for generating a data visualization, including: receiving an input data set comprising a plurality of data objects; receiving a first and second visualization type selections; generating a first and second visualization modules using the plurality of data objects and the first and second visualization type selections; receiving a selected connector option from a plurality of selectable connector options; and generating a dynamic visualization by connecting the first visualization module and the second visualization module using the selected connector option.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 sets forth a block diagram of automated computing machinery comprising an example computer useful in generating a data visualization according to embodiments of the present disclosure.

Figure 2 illustrates a flowchart of an example method for generating a data visualization according to embodiments of the present disclosure.

Figure 3 illustrates an example input data set for generating a data visualization according to embodiments of the present disclosure.

5 Figure 4 illustrates an example first visualization module for generating a data visualization according to embodiments of the present disclosure.

Figure 5 illustrates an example second visualization module for generating a data visualization according to embodiments of the present disclosure.

10 Figure 6 illustrates an example interface for the module selector interface module according to embodiments of the present disclosure.

Figure 7 illustrates an example interface for the connection option interface according to embodiments of the present disclosure.

15 Figure 8 illustrates an example data visualization according to embodiments of the present disclosure.

20 Figure 9 illustrates a flowchart of an example method for tracking objects in real-time (or substantially real-time) in order to generate a data visualization according to embodiments of the present disclosure.

Figure 10 illustrates another example of a data visualization according to embodiments of the present disclosure.

25 Figure 11 illustrates another example of a data visualization according to embodiments of the present disclosure.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Example methods, apparatuses, and products for generating a data visualization in accordance with the present invention are described with reference to the accompanying drawings, beginning with Figure 1. Figure 1 sets forth a block diagram of automated computing machinery comprising an example computer (152) useful in generating a data visualization according to embodiments of the present disclosure. The computer (152) of Figure 1 includes at least one computer processor (156) or 'CPU' as well as random access memory (168) ('RAM') which is connected through a high speed memory bus (166) and bus adapter (158) to processor (156) and to other components of the computer (152).

Stored in RAM (168) is a visualization generator (115), a module of computer program instructions for generating a data visualization according to certain embodiments of the present disclosure. The visualization generator (115) of Figure 1 includes at least one data uploading interface module (110), a module of computer program instructions operable to receive an input data set comprising a plurality of data objects. The visualization generator (115) of Figure 1 also includes at least one module selector interface (111), a module of computer program instructions operable to display a plurality of selectable visualization types, receive a first visualization type selection, and receive a second visualization type selection. The visualization generator (115) of Figure 1 also includes at least one visualization module generator (112), a module of computer program instructions operable to generate a first and a second visualization module using the plurality of data objects and the first and second visualization type selections, respectively. The visualization generator (115) of Figure 1 also includes at least one visualization store (113), a module of computer program instructions operable to store one or more visualization modules. The visualization generator (115) of Figure 1 also includes at least one connection option interface (114), a module of computer program instructions operable to display a plurality of selectable connector options to connect the first visualization module to

the second visualization module, and to receive a selected connector option from the plurality of selectable connector options.

The visualization generator (115) may be operable to generate a dynamic visualization by connecting the first visualization module and the second visualization module using the selected connector option. The visualization generator (115) may be further operable to receive a user input indicating that a user has modified an aspect of the dynamic visualization scheme, and in response to receiving the user input, regenerate the dynamic visualization to reflect the user input.

In some embodiments, the visualization generator (115) may be further operable to detect a trigger on a portion of the first visualization module, wherein the portion identifies a particular data object of the plurality of data objects; determine a particular unique identifier for the particular data object; identify a portion of the second visualization module that depicts the particular data object using the particular unique identifier; and in response to detecting the trigger, highlight the portion of the first visualization that depicts the particular data object, and highlighting the portion of the second visualization module that depicts the particular data object.

Also stored in RAM (168) is an operating system (154). Operating systems useful generating a data visualization according to embodiments of the present invention include UNIXTM, LinuxTM, Microsoft XPTM, AIXTM, IBM's i5/OSTM, and others as will occur to those of skill in the art. The operating system (154), data uploading interface (206), module selector interface (208), visualization module generator (210), visualization store (212), connection option interface (214), and visualization generator (216) in the example of Figure 1 are shown in RAM (168), but many components of such software typically are stored in non-volatile memory also, such as, for example, on a disk drive (170).

The computer (152) of Figure 1 includes disk drive adapter (172) coupled through expansion bus (160) and bus adapter (158) to processor (156) and other components

of the computer (152). Disk drive adapter (172) connects non-volatile data storage to the computer (152) in the form of disk drive (170). Disk drive adapters useful in computers for generating a data visualization according to embodiments of the present invention include Integrated Drive Electronics ('IDE') adapters, Small
5 Computer System Interface ('SCSI') adapters, and others as will occur to those of skill in the art. Non-volatile computer memory also may be implemented for as an optical disk drive, electrically erasable programmable read-only memory (so-called 'EEPROM' or 'Flash' memory), RAM drives, and so on, as will occur to those of skill in the art.

10

The example computer (152) of Figure 1 includes one or more input/output ('I/O') adapters (178). I/O adapters implement user-oriented input/output through, for example, software drivers and computer hardware for controlling output to display devices such as computer display screens, as well as user input from user input
15 devices (181) such as keyboards and mice. The example computer (152) of Figure 1 includes a video adapter (209), which is an example of an I/O adapter specially designed for graphic output to a display device (180) such as a display screen or computer monitor. Video adapter (209) is connected to processor (156) through a high speed video bus (164), bus adapter (158), and the front side bus (162), which is
20 also a high speed bus.

The example computer (152) of Figure 1 includes a communications adapter (167) for data communications with other computers (182) and for data communications with a data communications network (100). Such data communications may be carried out
25 serially through RS-232 connections, through external buses such as a Universal Serial Bus ('USB'), through data communications networks such as IP data communications networks, and in other ways as will occur to those of skill in the art. Communications adapters implement the hardware level of data communications through which one computer sends data communications to another computer,
30 directly or through a data communications network. Examples of communications adapters useful for generating a data visualization according to embodiments of the

present invention include modems for wired dial-up communications, Ethernet (IEEE 802.3) adapters for wired data communications network communications, and 802.11 adapters for wireless data communications network communications.

5 For further explanation, Figure 2 illustrates a flowchart of an example method (200) for generating a data visualization according to certain embodiments of the present disclosure. The method (200) depicted in Figure 2 includes receiving (205) an input data set comprising a plurality of data objects via a data uploading interface. The data uploading interface may allow users to upload datasets into the data visualization
10 system. One type of example data that may be particularly suited to method (200) includes proteomics data, although the method (200) may be applicable to a variety of different types of data. Once the input data set is received (205), the method (200) depicted in Figure 2 may proceed by displaying (210) a plurality of selectable visualization types. In such an example, a module selector interface may be
15 configured to display (210) a plurality of selectable visualization types. Once the a plurality of selectable visualization types have been displayed (210), the method (200) depicted in Figure 2 may proceed by receiving (215) a first visualization type selection and also receiving (218) a second visualization type selection. For example, one type of visualization module may be a heat map, while another type of
20 visualization module may be a survival curve, as described in more detail below with reference to Figures 3–8. After receiving (215, 218) the visualization type selections, the method (200) depicted in Figure 2 may proceed by generating (220) a first visualization module using the data objects and the first visualization type selection and also generating (223) a second visualization module using the data objects and
25 the second visualization type selection.

The method depicted in Figure 2 also includes displaying (225) a plurality of selectable connector options to connect the first visualization module to the second visualization module. The plurality of selectable connector options to connect the
30 first visualization module to the second visualization module may be displayed (225), for example, by a connection option interface. The method (200) depicted in Figure 2

may then proceed by the connection option interface receiving (228) a selected connector option from the plurality of selectable connector options. After the selected connector option is received (228) from the plurality of selectable connector options, the method (200) depicted in Figure 2 may continue by generating (235) a
5 dynamic visualization by connecting the first visualization module and the second visualization module using the selected connector option.

In some embodiments, the dynamic visualization may include a dynamic web page or other appropriate data interaction mechanism. A user of the method (200) depicted in
10 Figure 2 may be able to create an interactive map by selecting and dragging different elements out of a selection screen. For example, when rendering these images using JavaScript in a web browser, one may save these demos to an interactive webpage that clients or scientists can interact with. These maps may have streamlined presentation connection so the charts and figures that may be more easily uploaded.

15 Although Figure 2 illustrates a method (200) occurring in a particular order, certain deviations from the example order may be understood by one of ordinary skill in the art without departing from the scope of the present disclosure. For example, although receiving (218) a second visualization type is illustrated as occurring after receiving
20 (215) a first visualization type, both steps may occur simultaneously. Likewise, generating (220) a first visualization module and generating (223) a second visualization module may also occur simultaneously. Further, although the method (200) is illustrated as beginning by receiving (205) an input data set, other points may be appropriate as a beginning for the method (200) without departing from the scope
25 of the present disclosure. For example, the method (200) may include a regeneration of a dynamic visualization, and may therefore begin by displaying (225) a plurality of selectable connector options.

In some embodiments, the method (200) may include additional processes. For
30 example, the method (200) may also include receiving a user input indicating that a user has modified an aspect of the dynamic visualization scheme and, in response to

receiving the input, the method (200) may regenerate the dynamic visualization to reflect the user input. For example, by clicking on a protein name in a circular heat chart, patients may be arranged based on protein expression level. Then, the user may click and drag the rings to reposition them. Grouping and sorting functionalities
5 may give scientists the abilities to better visualize their conclusions. For instance, a study on proteomics in Acute Myeloid Leukemia (AML) at MD Anderson generates a dataset of over 500 patients, over 230 protein expression levels and over 80 clinical correlates for each patient. The variety of data types include survival data, protein expression data, mutation profile, demographic data (e.g. gender) and clinical
10 diagnostic data (e.g. blood count). The method (200) may allow researchers to better visualize this data. In addition these modules may be able to be connected through object tracking, as described in more detail below with reference to Figure 9.

Figure 3 illustrates an example input data set (300) for generating a data visualization,
15 in accordance with certain embodiments of the present disclosure. In the example input data set (300), a set of patients is identified with a corresponding plurality of protein expression levels, as well as certain demographic data. Although example data is illustrated here, other types of data, as well as data sizes and schemes may be implemented without departing from the scope of the present disclosure.

20

Figure 4 illustrates an example first visualization module (400) for generating a data visualization, in accordance with certain embodiments of the present disclosure. Example visualization module (400) is a circular heat map, wherein each wedge represents a different patient, an each inner ring is a different protein. The outer rings
25 denote a grouping based on certain demographic data (e.g., male or female).

Figure 5 illustrates an example second visualization module (500) for generating a data visualization, in accordance with certain embodiments of the present disclosure. Example visualization module (500) is a survival curve based on clinical correlates.
30 This information could be contained in the same data used to plot example visualization module (400).

Figure 6 illustrates an example interface (600) for the module selector interface module (111), in accordance with certain embodiments of the present disclosure. The example interface (600) includes an individual module property selector (602), a plurality of module selector objects (604), and a current module (606). For example, users may use the module selector objects (604) to select or change the module to be modified. Users may use the individual module property selector (602) to modify properties of individual modules, which may then be illustrated at the current module (606).

Figure 7 illustrates an example interface (700) for the connection option interface (114), in accordance with certain embodiments of the present disclosure. The example interface (700) includes first module (702) and second module (704). Example interface (700) may be used by a user to define portions of first module (702) that may be selectable by a user in order to interact with portions of second module (702).

Figure 8 illustrates an example data visualization (800), in accordance with certain embodiments of the present disclosure. The example data visualization (800) may result in a visualization of the input data set based on certain user input, as described in more detail above with reference to Figures 1–7. For example, the data visualization (800) depicted in Figure 7 illustrates AB7 in a manner that is organized by increasing level within each correlate.

Referring again to Figure 2, in some embodiments, receiving the input data set may include assigning a unique identifier to each of the plurality of data objects. This may allow for tracking objects in real-time (or substantially real-time) as a user interacts with a data visualization.

Figure 9 illustrates a flowchart of an example method (900) for tracking objects in real-time (or substantially real-time) in order to generate a data visualization, in accordance with certain embodiments of the present disclosure. The example method

(900) depicted in Figure 9 can include assigning (902) a unique identifier to each of a plurality of objects, as described above. After a unique identifier has been assigned (902) to each of a plurality of objects, the method (900) depicted in Figure 9 may continue by detecting (904) a trigger on a portion of a first visualization module, wherein the portion identifies a particular data object of the plurality of data objects. After detecting the trigger, the method (900) depicted in Figure 9 may continue by determining (906) a particular unique identifier for the particular data object. The example method (900) depicted in Figure 9 may subsequently identify (908) a portion of a second visualization module that depicts the particular data object using the particular unique identifier. The example method (900) depicted in Figure 9 may continue by highlighting (910), in response to detecting the trigger, the portion of the first visualization that depicts the particular data object and also highlighting the portion of the second visualization module that depicts the particular data object.

Although the steps depicted in Figure 9 are illustrated as occurring in a particular order, deviations may be made from the illustration of the example method (900) by one of ordinary skill in the art without departing from the scope of the present disclosure. For example, in some configurations, the particular unique identifier for the particular data object (e.g., 906) may be continuously tracked and/or cached, and/or large numbers of unique identifiers may be tracked and/or cached in order to improve performance.

In some web-based visualization design environments, each graphic element may be associated with an object or an object feature, e.g. a drop point on a survival curve links to a patient passed away at that time point. A user interaction mechanism may include any appropriate user interaction with the data visualization. For example, a user may mouse-over on a web page, touch a touch screen, etc. Once this trigger is received, the object ID may be returned. Subsequently, graphic elements associated with the same object may be highlighted in all visualization modules. The highlighting event can take various forms, including but not limited to drawing circles/boxes around the graphic element and changing the color, the intensity, the

saturation, or the width of the element. This display of all information regarding single object links all individual visualizations together in a meaningful way may allow for comparison and analysis across different data types and dimensions.

In some embodiments, the example method (900) depicted in Figure 9 includes
5 assigning (902) a unique identifier, detecting (904) a trigger, determining (906) a particular unique identifier for each data object, identifying (908) a portion of the second visualization module that depicts the data object, and highlighting (910) portions of each visualization, more, fewer, or different steps without departing from the scope of the present disclosure.

10

Tracking objects in real-time (or substantially real-time) may allow for improved visualization within a data visualization. For example, Figure 10 illustrates another example data visualization (1000), in accordance with certain embodiments of the present disclosure. The example data visualization (1000) may include a first
15 visualization module (1002) and a second visualization module (1004). In some embodiments, the visualization modules (1002, 1004) may include visualizations of related data. When a user interacts with the data visualization (1000), for example, by selecting a portion of the second visualization module (1004) as illustrated, a corresponding portion of the first visualization module (1002) may be highlighted as
20 illustrated. In the illustrated example visualization modules, object tracking may be triggered from a selection of a data point on the survival curve illustrated as the second visualization module (1004). As a result of the trigger and the corresponding object tracking, the expression of the corresponding patient may be highlighted simultaneously on the circular heat map illustrated as a first visualization module
25 (1002).

As a result of object tracking, the data visualization may be achieved regardless of which data visualization module the user interacts with. Figure 11 illustrates the example data visualization (1000) described in more detail above with reference to
30 Figure 10, in accordance with certain embodiments of the present disclosure. In Figure 11, the example data visualization (1000) may include a first data visualization

module (1102) and a second data visualization module (1104). When a user interacts with the data visualization (1000), for example, by selecting a portion of a first visualization module (1102) as illustrated, a corresponding portion of the second visualization module (1104) may be highlighted as illustrated. In the illustrated
5 example visualization modules, object tracking may be triggered from a selection of a patient-associated expression element within the pink (unfavorable cytogenetic group) segment of the circular heat map illustrated as the first visualization module (1102). As a result of the trigger and the corresponding object tracking, the data point corresponding to that patient may be highlighted simultaneously on the survival curve
10 illustrated as a second visualization module (1104).

Exemplary embodiments of the present disclosure are described largely in the context of a fully functional computer system for generating a data visualization. Readers of skill in the art will recognize, however, that the present invention also may be
15 embodied in a computer program product disposed upon computer readable storage media for use with any suitable data processing system. Such computer readable storage media may be any storage medium for machine-readable information, including magnetic media, optical media, or other suitable media. Examples of such media include magnetic disks in hard drives or diskettes, compact disks for optical
20 drives, magnetic tape, and others as will occur to those of skill in the art. Persons skilled in the art will immediately recognize that any computer system having suitable programming means will be capable of executing the steps of the method of the invention as embodied in a computer program product. Persons skilled in the art will recognize also that, although some of the exemplary embodiments described in this
25 specification are oriented to software installed and executing on computer hardware, nevertheless, alternative embodiments implemented as firmware or as hardware are well within the scope of the present invention.

It will be understood from the foregoing description that modifications and changes
30 may be made in various embodiments of the present invention without departing from its true spirit. The descriptions in this specification are for purposes of illustration

only and are not to be construed in a limiting sense. The scope of the present invention is limited only by the language of the following claims.

CLAIMS

What is claimed is:

1. A method of generating a data visualization, the method comprising:
 - receiving an input data set comprising a plurality of data objects;
 - receiving a first visualization type selection;
 - receiving a second visualization type selection;
 - generating a first visualization module using the plurality of data objects and the first visualization type selection;
 - generating a second visualization module using the plurality of data objects and the second visualization type selection;
 - receiving a selected connector option from the plurality of selectable connector options; and
 - generating a dynamic visualization, including connecting the first visualization module and the second visualization module using the selected connector option.
2. The method of claim 1, further comprising:
 - receiving a user input modifying an aspect of the dynamic visualization scheme; and
 - in response to receiving the user input, regenerating the dynamic visualization to reflect the user input.
3. The method of claim 2, wherein the user input comprises a dragging motion on an aspect of the dynamic visualization by a user interface indicator on an interface displaying the dynamic visualization.
4. The method of claim 2, wherein regenerating the dynamic visualization further comprises reorganizing the data objects comprising the dynamic visualization.

5. The method of claim 1, wherein receiving the input data set comprises assigning a unique identifier to each of the plurality of data objects.
6. The method of claim 5, further comprising:
 - detecting a trigger on a portion of the first visualization module, wherein the portion identifies a particular data object of the plurality of data objects;
 - determining a particular unique identifier for the particular data object;
 - identifying a portion of the second visualization module that depicts the particular data object using the particular unique identifier; and
 - in response to detecting the trigger, highlighting the portion of the first visualization that depicts the particular data object and highlighting the portion of the second visualization module that depicts the particular data object.
7. The method of claim 6, wherein the first visualization module is of a different visualization type than the second visualization module.
8. The method of claim 6, wherein the trigger is a mouse-over on the portion of the first visualization module corresponding to the particular data object.
9. The method of claim 6, further comprising, in response to detecting the trigger, displaying the particular unique identifier.
10. The method of claim 1, wherein the data objects comprises patient healthcare data.

11. An apparatus for generating a data visualization, the apparatus comprising a computer processor, a computer memory operatively coupled to the computer processor, the computer memory having disposed within it computer program instructions that, when executed by the computer processor, cause the apparatus to carry out the steps of:
 - receiving an input data set comprising a plurality of data objects;
 - receiving a first visualization type selection;
 - receiving a second visualization type selection;
 - generating a first visualization module using the plurality of data objects and the first visualization type selection;
 - generating a second visualization module using the plurality of data objects and the second visualization type selection;
 - receiving a selected connector option from the plurality of selectable connector options; and
 - generating a dynamic visualization by connecting the first visualization module and the second visualization module using the selected connector option.
12. The apparatus of claim 11, further comprising computer program instructions that, when executed by the computer processor, cause the apparatus to carry out the steps of:
 - receiving a user input modifying an aspect of the dynamic visualization scheme; and
 - in response to receiving the user input, regenerating the dynamic visualization to reflect the user input.
13. The apparatus of claim 11, wherein receiving the input data set further comprises assigning a unique identifier to each of the plurality of data objects.

14. The apparatus of claim 13, further comprising computer program instructions that, when executed by the computer processor, cause the apparatus to carry out the steps of:
 - detecting a trigger on a portion of the first visualization module, wherein the portion identifies a particular data object of the plurality of data objects;
 - determining a particular unique identifier for the particular data object;
 - identifying a portion of the second visualization module that depicts the particular data object using the particular unique identifier; and
 - in response to detecting the trigger, highlighting the portion of the first visualization that depicts the particular data object, and highlighting the portion of the second visualization module that depicts the particular data object.
15. The apparatus of claim 14, wherein the first visualization module is of a different visualization type than the second visualization module.
16. The apparatus of claim 14, further comprising computer program instructions that, when executed by the computer processor, cause the apparatus to carry out the steps of, in response to detecting the trigger, displaying the particular unique identifier.

17. A computer program product for generating a dynamic visualization scheme, the computer program product disposed upon a computer readable medium, the computer program product comprising computer program instructions that, when executed, cause a computer to carry out the steps of:
 - receiving an input data set comprising a plurality of data objects;
 - receiving a first visualization type selection;
 - receiving a second visualization type selection;
 - generating a first visualization module using the plurality of data objects and the first visualization type selection;
 - generating a second visualization module using the plurality of data objects and the second visualization type selection;
 - receiving a selected connector option from the plurality of selectable connector options; and
 - generating a dynamic visualization by connecting the first visualization module and the second visualization module using the selected connector option.
18. The computer program product of claim 17, further comprising computer program instructions that, when executed, cause the computer to carry out the steps of:
 - receiving a user input modifying an aspect of the dynamic visualization scheme; and
 - in response to receiving the user input, regenerating the dynamic visualization to reflect the user input.
19. The computer program product of claim 18, wherein receiving the input data set further comprises assigning a unique identifier to each of the plurality of data objects.

20. The computer program product of claim 19, further comprising computer program instructions that, when executed by the computer processor, cause the computer to carry out the steps of:
- detecting a trigger on a portion of the first visualization module, wherein the portion identifies a particular data object of the plurality of data objects;
 - determining a particular unique identifier for the particular data object;
 - identifying a portion of the second visualization module that depicts the particular data object using the particular unique identifier; and
 - in response to detecting the trigger, highlighting the portion of the first visualization that depicts the particular data object, and highlighting the portion of the second visualization module that depicts the particular data object.

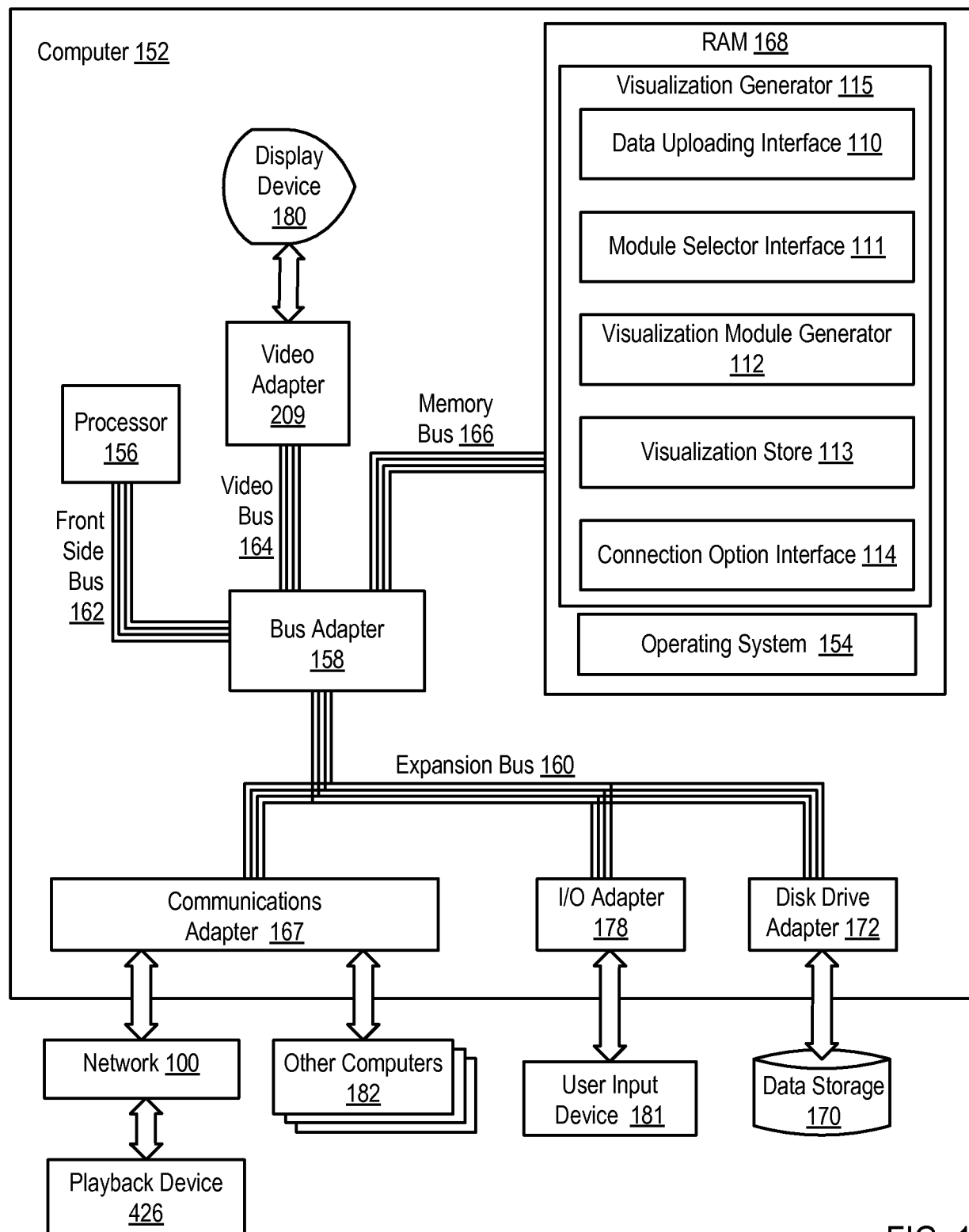


FIG. 1

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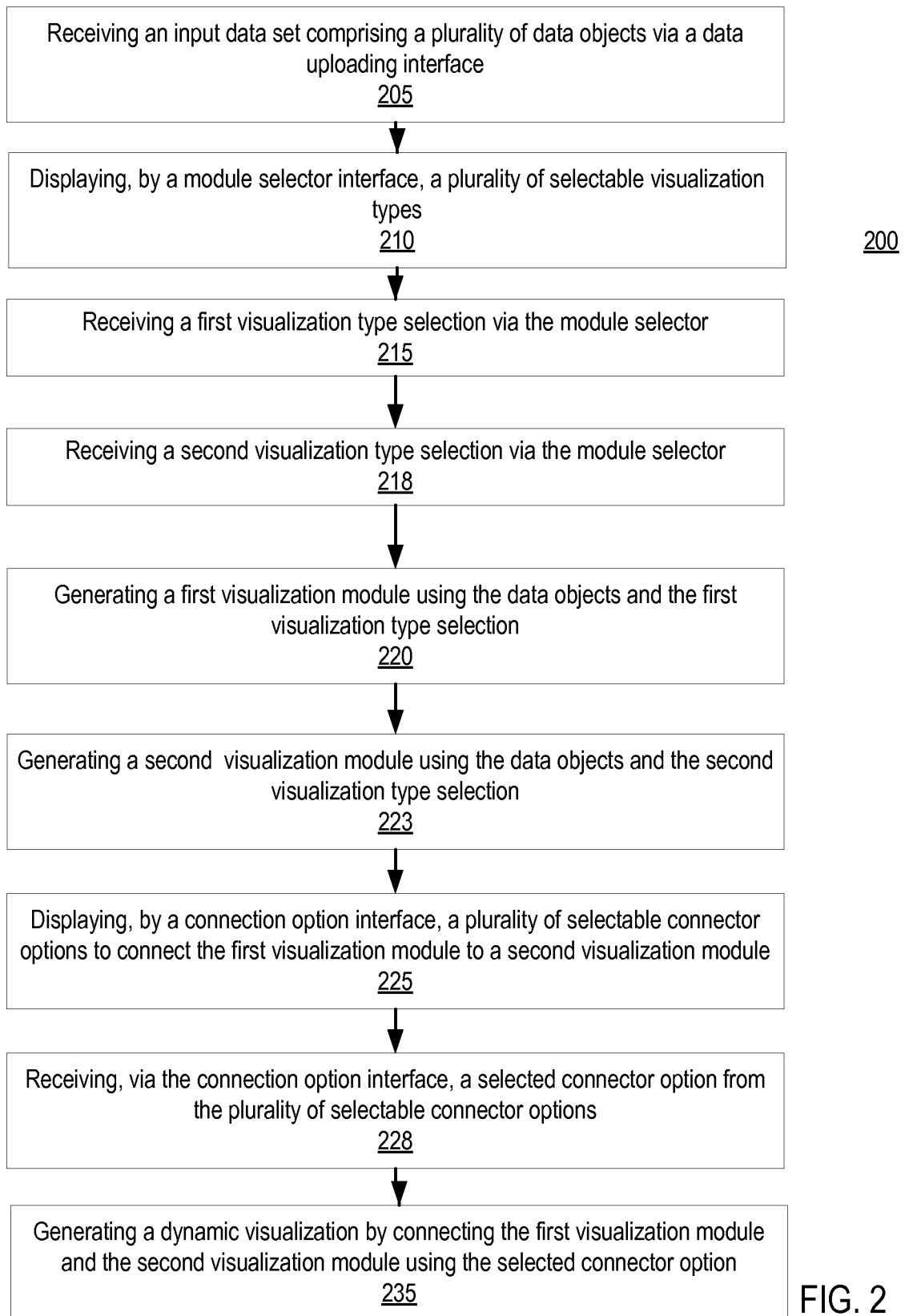
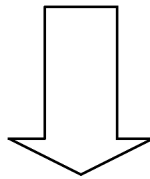


FIG. 2

3/11

300

Patient #	Protein Exp 1	Protein Exp 2	Gender	Age
1	0.024	3.1	M	45
2	-0.18	0.36	M	67
3	0.23	-0.56	F	52



```
[{"Patient #": 1, "Protein Exp 1": 0.024, "Protein Exp 2": 3.1, "Gender": "M", "Age": 45},  
{"Patient #": 2, "Protein Exp 1": -0.18, "Protein Exp 2": 0.36, "Gender": "M", "Age": 67},  
{"Patient #": 3, "Protein Exp 1": 0.23, "Protein Exp 2": -0.56, "Gender": "F", "Age": 52}]
```

FIG. 3

Clinical
Correlates

- ☒ CC4
- ☐ CC14
- ☐ CC18

Antibodies

- ☒ AB1
- ☒ AB2
- ☐ AB3
- ☐ AB4
- ☐ AB5
- ☐ AB6
- ☐ AB7
- ☐ AB8
- ☐ AB9
- ☐ AB10

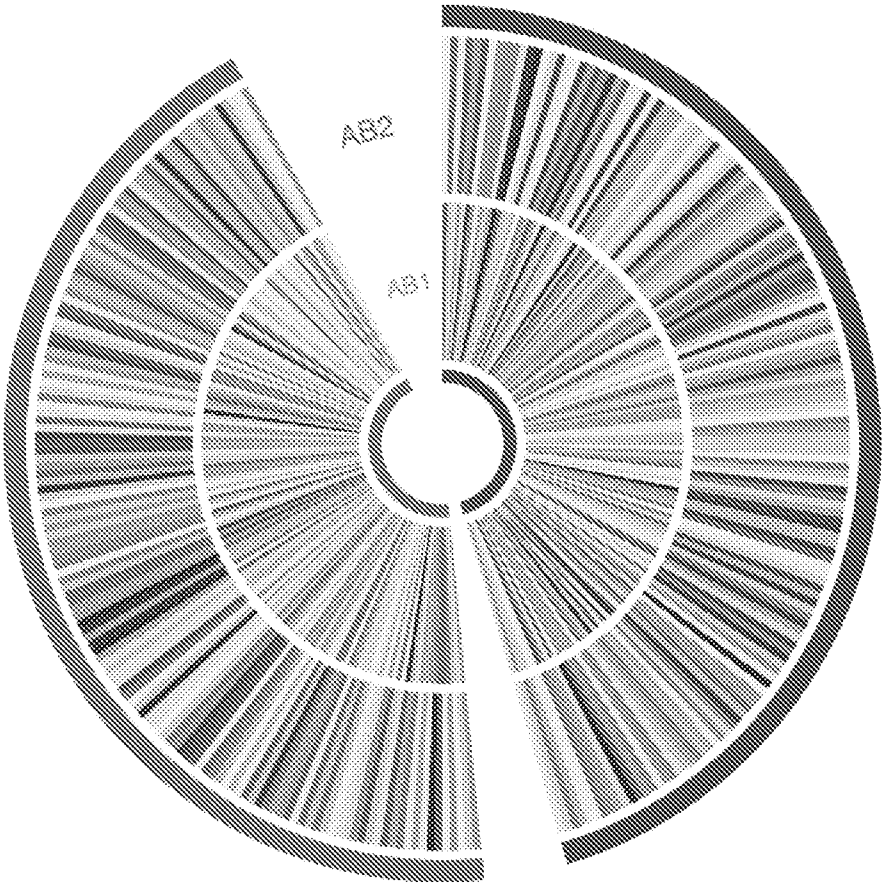


FIG. 4

500

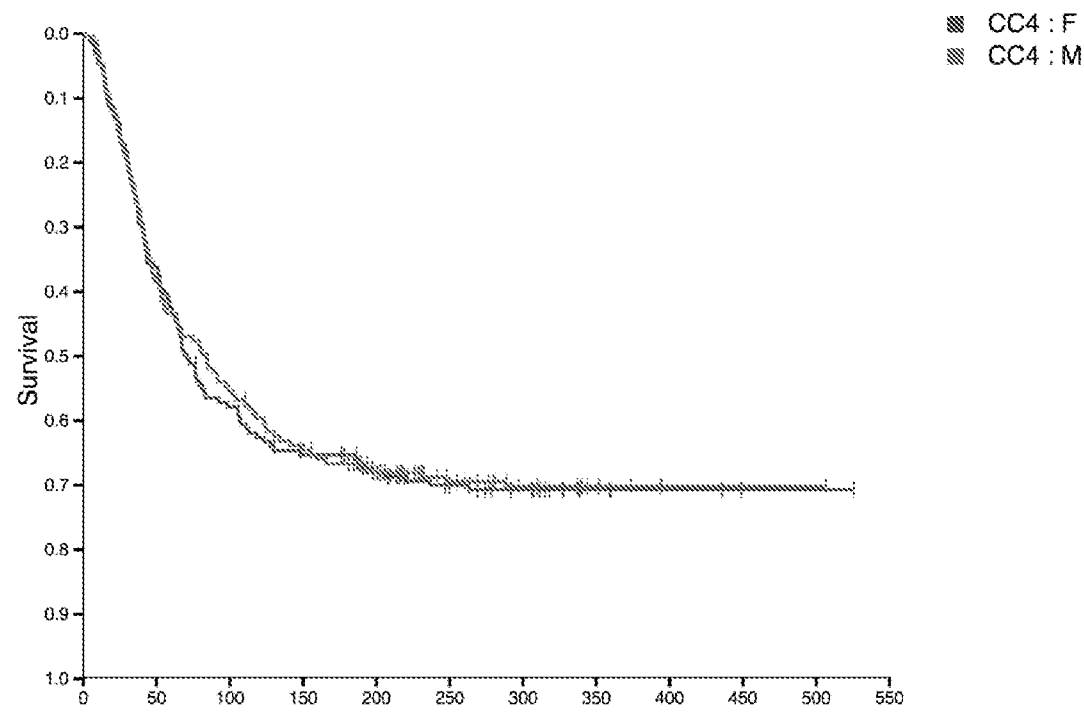


FIG. 5

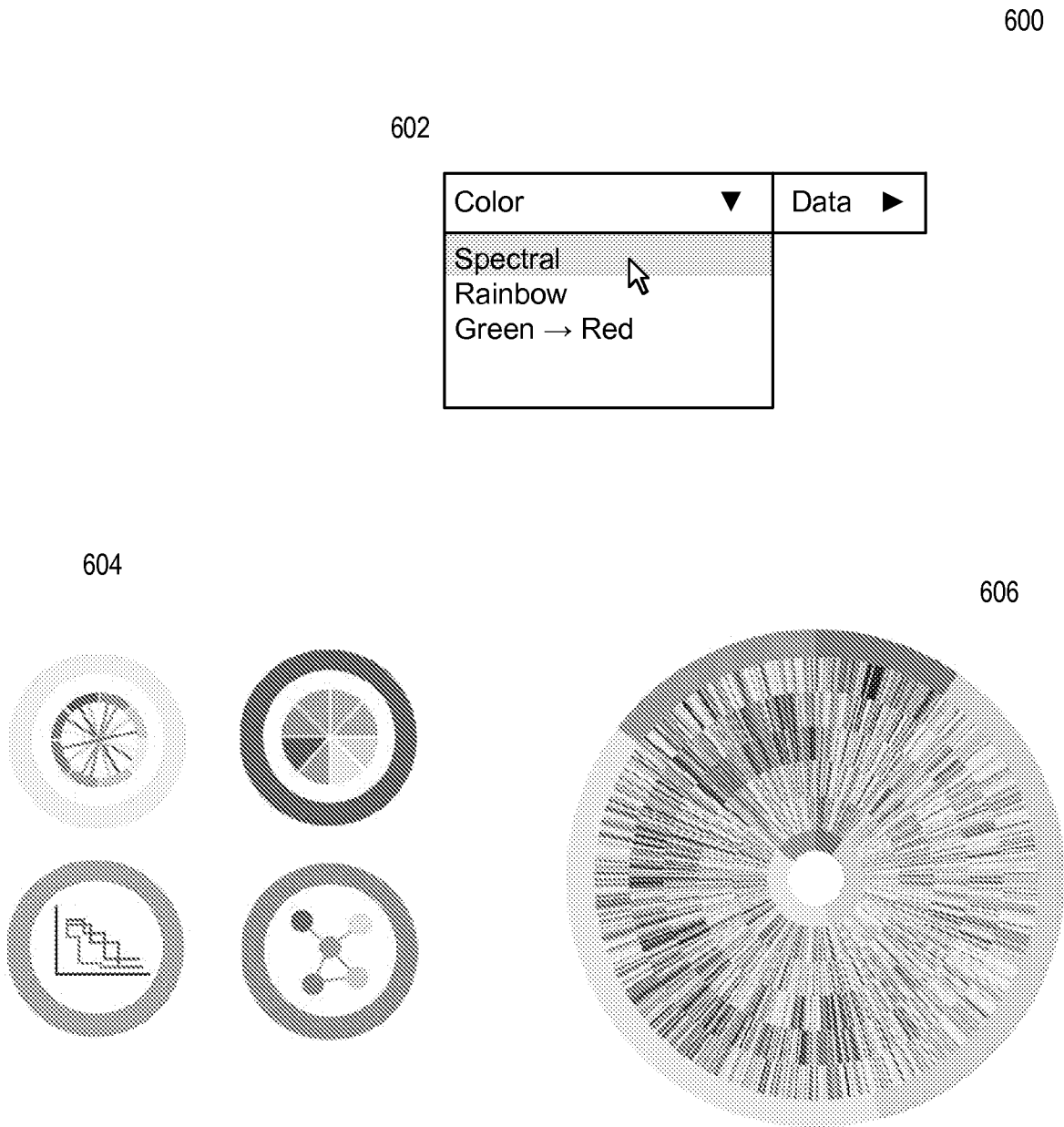


FIG. 6

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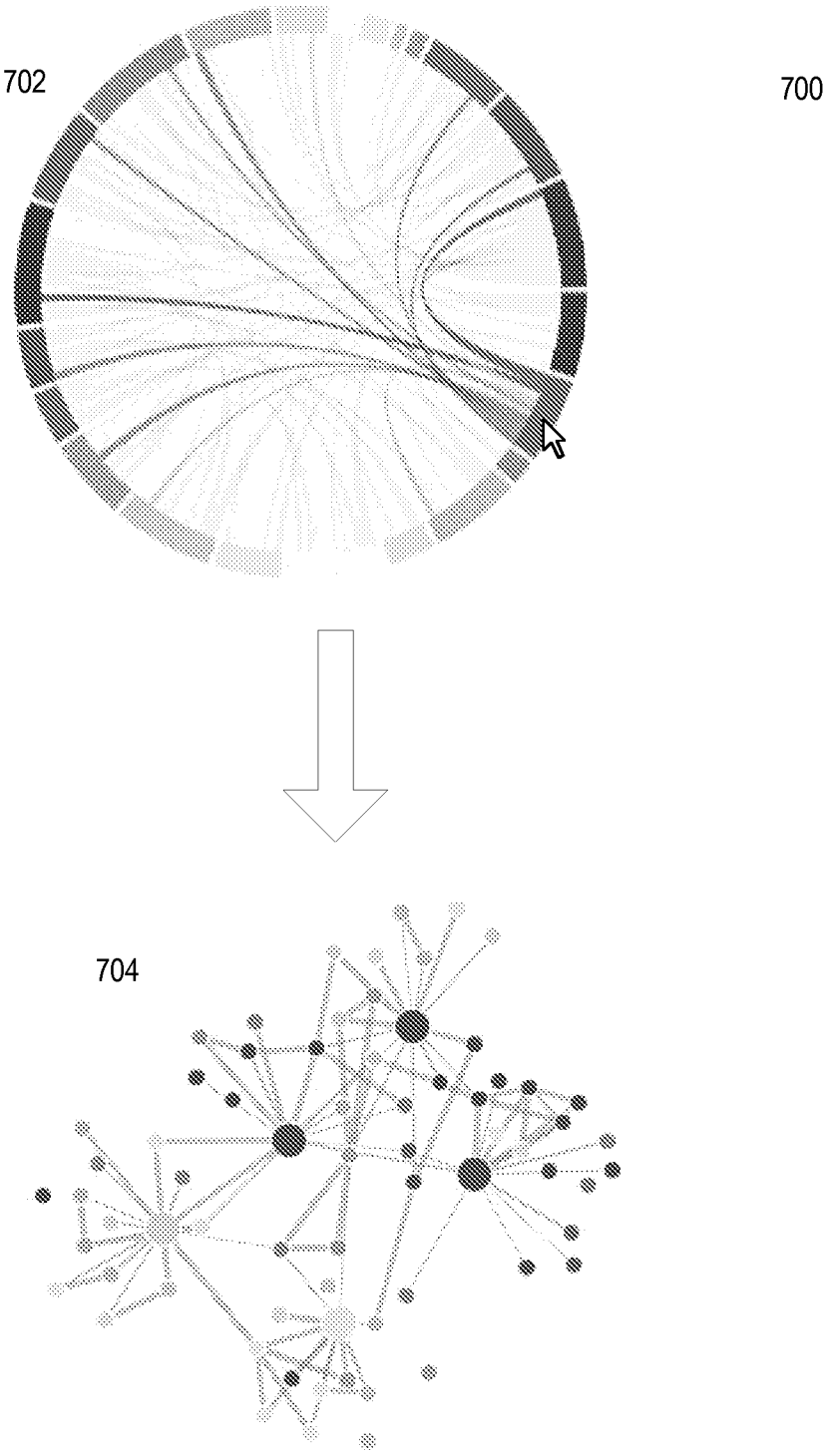


FIG. 7

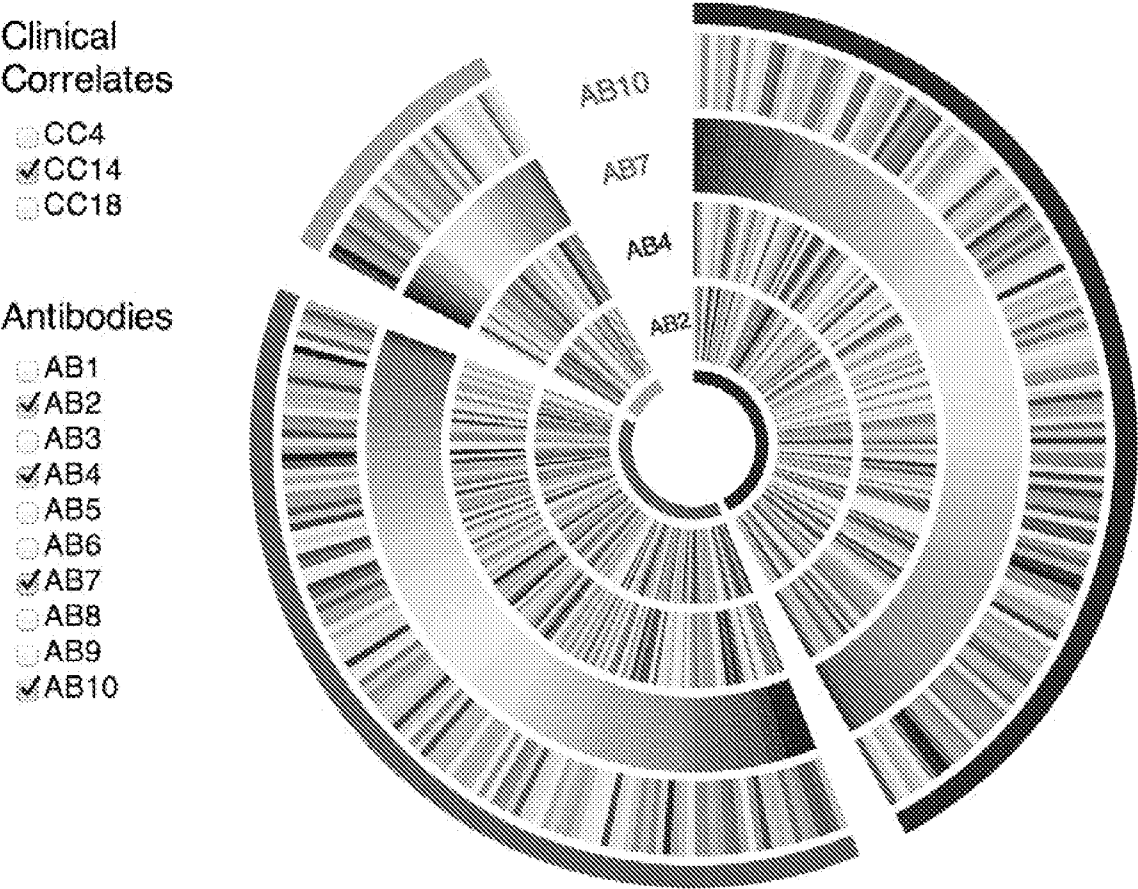


FIG. 8

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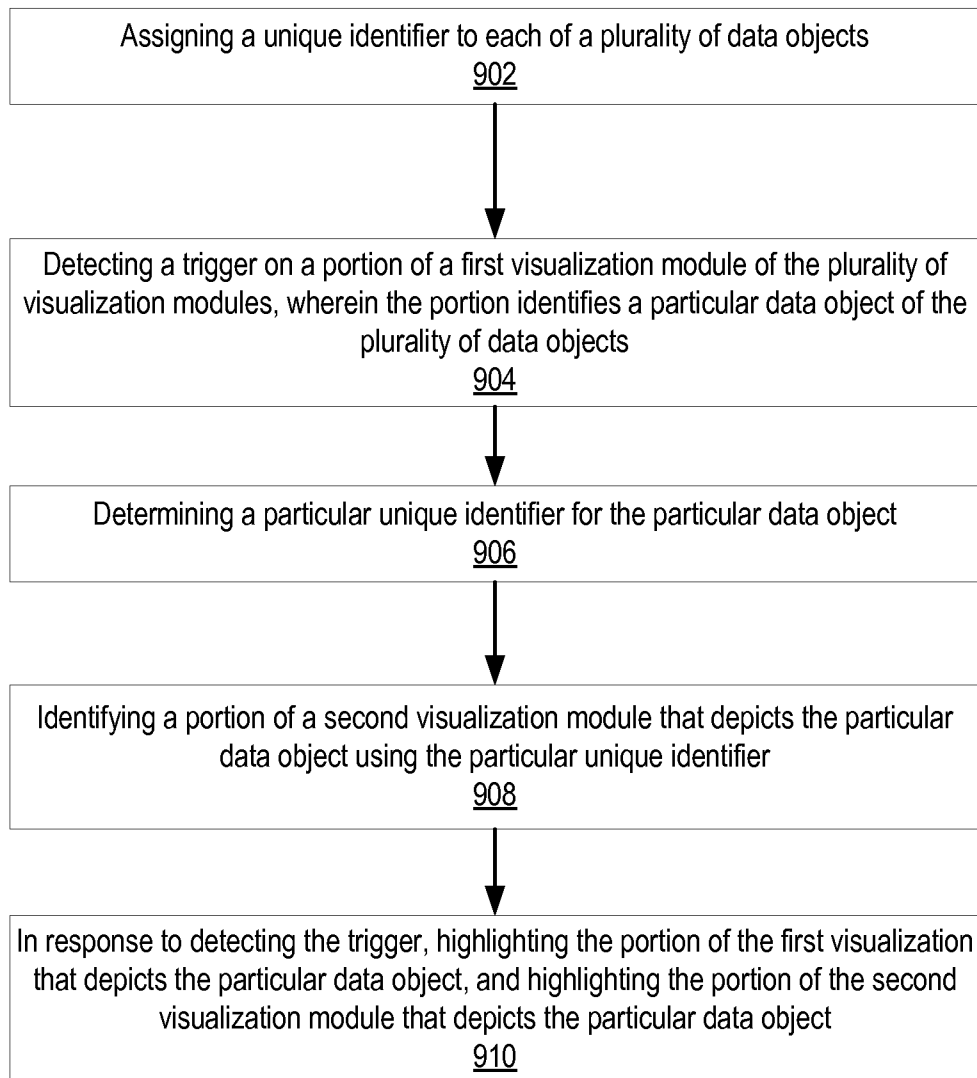


FIG. 9

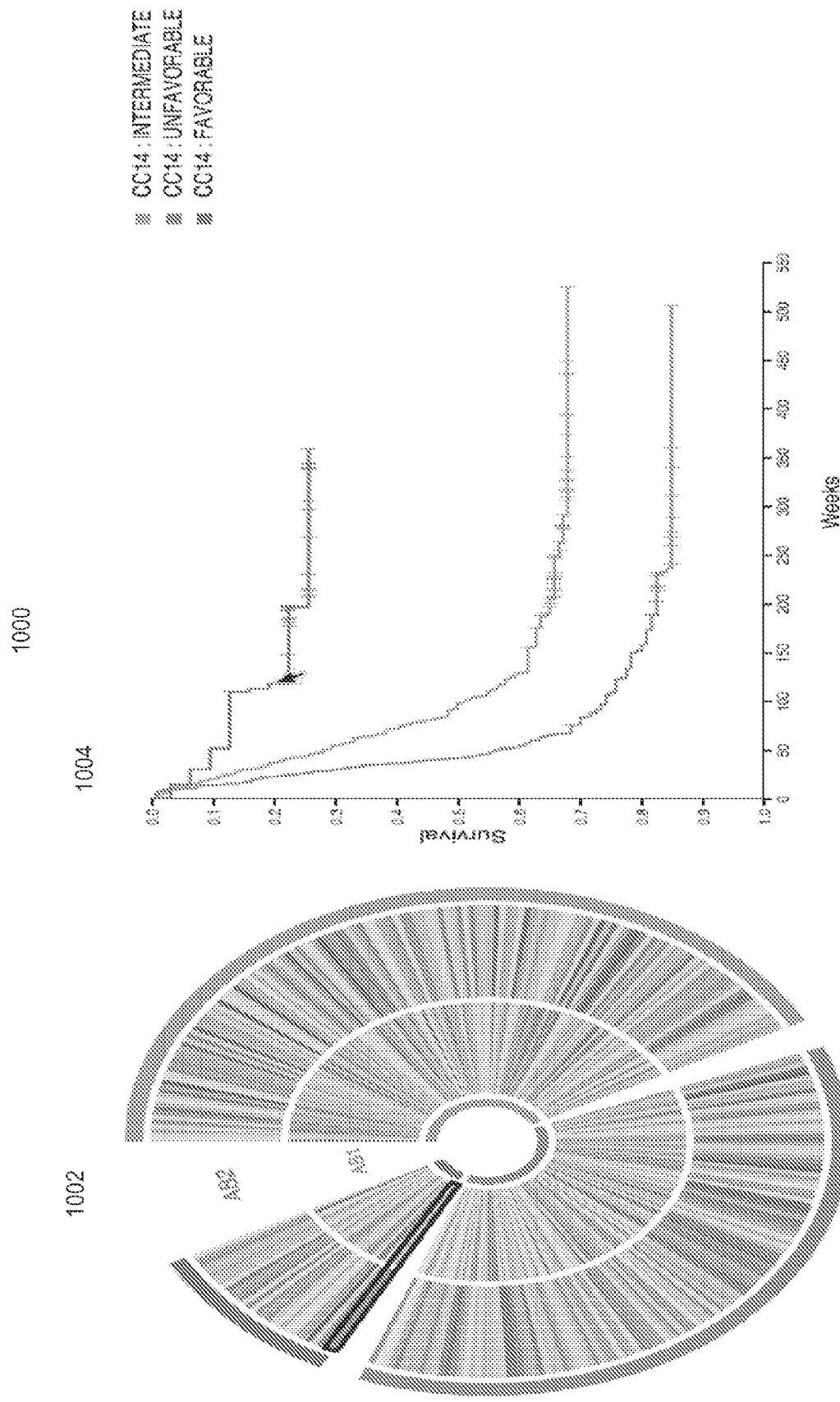


FIG. 10

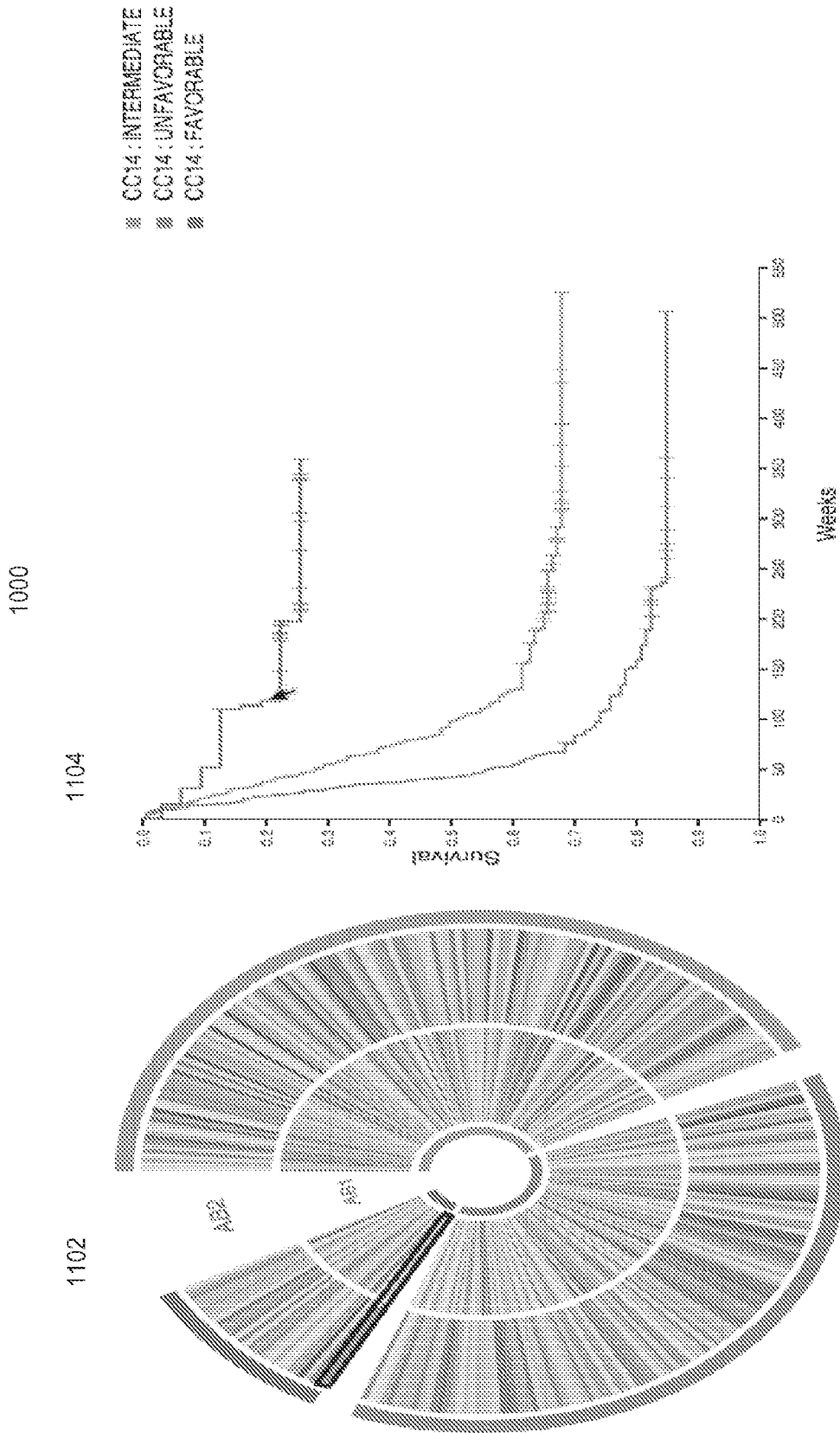


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/032376

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F19/26
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/313576 A1 (NEUMANN ULRICH [US] ET AL) 17 December 2009 (2009-12-17) the whole document -----	1-20
X	US 2004/241730 A1 (YAKHINI ZOHAR [IL] ET AL) 2 December 2004 (2004-12-02) the whole document -----	1-20
X	US 2012/290323 A1 (BARSOUM WAEL K [US] ET AL) 15 November 2012 (2012-11-15) the whole document -----	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

18 January 2016

Date of mailing of the international search report

26/01/2016

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/032376

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009313576	A1	17-12-2009	NONE
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