(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 July 2008 (17.07.2008)

PCT

(10) International Publication Number
WO 2008/086266 A2

(51) International Patent Classification:
G06F 7/06 (2006.01)

(21) International Application Number:
PCT/US2008/050370

(22) International Filing Date: 7 January 2008 (07.01.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/883,655 5 January 2007 (05.01.2007) US
60/970,125 5 September 2007 (05.09.2007) US

(71) Applicant *(for all designated States except US)*: **UNIVERSITY OF MASSACHUSETTS** [US/US]; 225 Franklin Street, Boston, Massachusetts 02110 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **GRINSTEIN, Georges** [US/US]; 151 Simonds Road, Ashby, Massachusetts 01431 (US). **GEE, Alexander** [US/US]; 109 Fairmount Street, Lowell, Massachusetts 01852 (US). **SMRTIC, Mary Beth** [US/US]; 6 Jennifer Drive, Westford, Massachusetts 01886 (US). **GUPTA, Vivek** [US/US]; 5 Betsy Lane, Littleton, Massachusetts 01460 (US).

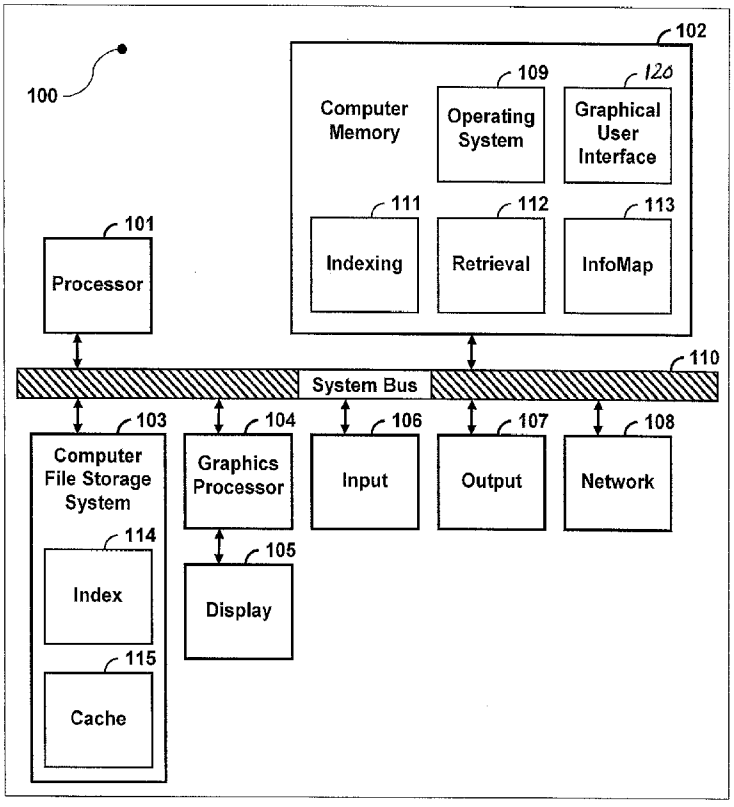
(74) Agent: **O'SHEA, Patrick**; O'Shea, Getz & Kosakowski, P.C., 1500 Main Street, Suite 912, Springfield, Massachusetts 01115 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),

[Continued on next page]

(54) Title: PERSONAL INFORMATION MAPS



(57) Abstract: An interactive visual interface for organizing, locating, searching, and monitoring collections of digital information, designed to harness human spatial memory for organizing and retrieving digital information. In one example, an information map organizes digital information within a two-dimensional space with rapid visual feedback and information access. The organization may be algorithmically computed and user-modified. An interface that supports persistent state information whereby search nodes and document references are spatially fixed so that users may harness their spatial memory to organize and find information quickly.

WO 2008/086266 A2

European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report*

UNITED STATES PATENT APPLICATION

of

GEORGES GRINSTEIN

ALEXANDER GEE

MARY BETH SMRTIC

and

VIVEK GUPTA

for

PERSONAL INFORMATION MAPS

PERSONAL INFORMATION MAPS

PRIORITY INFORMATION

This patent application claims priority from U.S. provisional patent application serial number 60/883,655 filed January 5, 2007 and U.S. provisional patent application serial number 60/970,125 filed September 5, 2007, both applications are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to organizing, locating, searching, and monitoring digital information that may be stored, for example, on a local or remote computer.

2. Description of the Relevant Art

Individuals and organizations are relying more and more on computer systems to store information digitally rather than in paper form. As collections of digital information become larger and more varied, including for example formatted and unformatted text files, images and photos, movies and videos, music and audio files, e-mails, contacts, calendar events, web links and pages, notes, etc., it is increasingly important to be able to locate, retrieve, organize, and manage the collections of information.

Most computer operating systems provide file systems that include, for example, file folders or pathways that allow users to organize stored information. These file systems typically provide search and browse functions that allow users access to stored files. File systems are generally hierarchical in structure.

In addition to locally stored digital information, digital content may be stored in remote computer systems connected on a local network or on the global Internet. Internet interfaces, such as Yahoo, Google and others, provide search engines to search for and locate the information. Search results may be stored, for example, by using the "favorite" link provided by many search engines, may be downloaded to a local computer and saved in the file system, or pushed and stored on a remote computer.

SUMMARY OF THE INVENTION

Aspects and embodiments of the invention are directed to a system that may provide a visual interface to large collections of digital information. The system may assist users by providing a graphical user interface designed to harness human spatial memory for organizing and retrieving digital information. As discussed below, embodiments of the invention may provide an interface for the spatial organization of digital information within a two or three-dimensional space with rapid visual feedback and information access. Embodiments of this invention may support persistent state information whereby digital information files are spatially fixed so that users may harness their spatial memory to organize and find information quickly. In addition to the graphical user interface, embodiments of this system may support access to multiple different search engines and sources of digital information.

According to one embodiment, a graphical user interface on a computer system may comprise at least one two-dimensional surface, and at least one search node positioned on the at least one two-dimensional surface, those search node being defined by at least one search criterion, zero or more document references associated with those search nodes, the zero or more document references containing metadata that links each document reference to a document

stored on the local computer or on a removable storage system or on a remote computer system, and the zero or more document references positioned within or around the associated at least one search node via a parameterized positioning function. In one example, the two-dimensional surfaces may include one or more background images. In another example, a location of the search nodes on the two-dimensional surface may be persistent with scaling of the two-dimensional surface.

In one example of the graphical user interface, a two-dimensional surface comprises a plurality of search nodes, each search node being defined by a set of search criteria. Furthermore, the plurality of search nodes may comprise a plurality of document references. In another example, each document reference of the plurality of document references link to a document stored on the local computer or on a removable storage system or on a remote computer system. In a further example, two or more document references of the plurality of document references for the plurality of search nodes may link to the same document stored on the local computer or on the removable storage system or on a remote computer system. In an additional example, the zero or more document references include selected or unselected states; furthermore, two or more document references of the plurality of document references linked to the same document may be selected if one of the associated two or more document references is selected. In another example, the plurality of search nodes includes selected or unselected states. In one example, the plurality of search nodes includes the search criteria of the one or more selected search nodes, and the plurality of document references for the plurality of search nodes reflects the change in related document references. In another example, for the one or more selected search nodes a new set of selection document references is defined by an intersection of document references in each of the one or more selected search nodes; those document

references that belong to all of one or more selected search nodes. Furthermore, the plurality of search nodes display only those document references intersecting with the set of selection document references.

In another embodiment, a two-dimensional surface comprise a plurality of landmarks, each landmark defined by a region on the two-dimensional surface containing zero or more area for some defined shape, the landmarks being defined by zero or more search criteria. In a further example, landmarks may overlap on the two-dimensional surface. In another example, the at least one two-dimensional surfaces may comprise a plurality of search nodes on the at least one two-dimensional surface positioned over one or more of the plurality of landmarks. In another example, the plurality of search nodes overlapping one or more of the plurality of landmarks may include the search criteria of the underlying landmarks. In an additional example, a set of landmark document references is defined for the plurality of landmarks; this set of landmark document references may or may not be visually displayed. Furthermore, the plurality of search nodes overlapping one or more of the plurality of landmarks may display only those document references intersecting with the set of landmark document references.

In an additional embodiment, a two-dimensional surface is defined by zero or more search criteria. The two-dimensional surface comprises a plurality of search nodes. In an example, the plurality of search nodes may include the search criteria of the at least one two-dimensional surface. In another example, a set of map document references is defined for the two-dimensional surface. Furthermore, the plurality of search nodes may display only those document references intersecting with the set of map document references. In a further example, the at least one two-dimensional surface may comprise a plurality of landmarks and overlapping plurality of search nodes positioned over one or more of the plurality of landmarks. In an

example, the plurality of search nodes may include the search criteria of the two-dimensional surfaces and the underlying landmarks. In a further example, the plurality of search nodes may display only those document references intersecting with the set of map document references and the set of landmark document references.

In another embodiment, a two-dimensional surface is defined by zero or more search criteria. The two-dimensional surfaces comprise a plurality of search nodes. In an example, the plurality of search nodes will include the search criteria of the two-dimensional surfaces. In another example, a set of map document references is defined for the two-dimensional surfaces. Furthermore, the plurality of search nodes will display only those document references intersecting with the set of map document references. In a further example the layout of document references within the two-dimensional surface is computed using a parameterized positioning vector function with customizable coefficients for defining document reference layouts that include document metadata and semantics. For example document references with deadlines may be placed to the right of search nodes colored by projects, sized by order of importance, emails to be placed above search nodes with similar attributes, and other positioning criteria based on the semantics of the documents. In a further example a user may move a selected document reference, change its attributes and have that document reference appear in other search nodes or information maps.

In a further embodiment, a two-dimensional surface comprises a toolbar and the toolbar may comprise a text input device and this text input device defines a query search across the plurality of search nodes. In another example, the plurality of search nodes may include the search criteria of the defined query search, and the plurality of document references for the plurality of search nodes may reflect the change in related document references. In another

example, a set of search document references is defined for the query search. Furthermore, the plurality of search nodes may display only those document references intersecting with the set of search document references. In a further example, the plurality of search nodes may display only those document references intersecting with both the set of selection document references and the set of search document references.

In an additional embodiment, a two-dimensional surface comprises a toolbar and the toolbar may comprise a plurality of links to corresponding search filters, each search filter being defined by at least one search criterion. Furthermore, the plurality of search filters includes selected or unselected states. In one example, the plurality of search nodes include the search criteria of the one or more selected search filters, and the plurality of document references for the plurality of search nodes reflect the change in related document references. In another example, a set of filtered document references is defined for the one or more selected search filters. Furthermore, the plurality of search nodes will display only those document references intersecting with the set of filtered document references. In a further example, the plurality of search nodes will display only those document references intersecting with the set of selection document references, the set of search document references, and the set of filtered document references.

These and other objects, features and advantages of the present invention will become more apparent in light of the following detailed description of preferred embodiments thereof, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Various aspects and embodiments of the invention are discussed below with reference to the accompanying drawings. These drawings are not intended to be drawn to scale. In the drawings, each identical or nearly identical component that is illustrated in various figures is represented by a like reference numeral. For purposes of clarity, not every component may be labeled in every drawing. In the drawings:

Fig. **1** is a block diagram illustrates a computer architecture and operating environment for implementation;

Fig. **2** is a block diagram illustrates the primary components of an embodiment of the present invention;

Fig. **3** is an information map window user-interface including a map, search control, filters control, and results control;

Fig. **4** depicts a general information map containing a set of search nodes;

Fig. **5** depicts an information map containing only landmarks;

Fig. **6** depicts an information map containing only landmarks associated to an underlying image;

Fig. **7** depicts an information map containing only anchors;

Fig. **8** depicts an information map combining landmarks and anchors;

Fig. **9** depicts an information map displaying the layout of document references for individual landmarks and anchors;

Fig. **10** depicts an information map displaying the custom layout of document references for landmarks and anchors;

Fig. **11** depicts potential graphical representations of document references;

Fig. **12** depicts potential thumbnail representations of custom document references;

Fig. **13** depicts potential document reference mouse-over thumbnail representations and document details;

Fig. **14** depicts the drag-and-drop user interaction for positioning search nodes;

Fig. **15** depicts selection of search nodes and the graphical representations of related document references;

Fig. **16** depicts the drag-and-drop user interaction of document references between search nodes;

Fig. **17** depicts the drag-and-drop user interaction of document references from a search node to defining new search nodes;

Fig. **18** depicts the drag-and-drop user interaction of documents in to an existing search node;

Fig. **19** depicts the drag-and-drop user interaction of documents onto a map defining new search nodes;

Fig. **20** depicts the drag-and-drop user interaction of copying document references out of the map as documents;

Fig. **21** depicts the drag-and-drop user interaction of moving folders onto a map defining new search nodes;

Fig. **22** depicts the drag-and-drop user interaction applied to exporting search nodes out of the information map and on to the desktop environment;

Fig. **23** depicts the general search of an information map for related documents;

Fig. **24** depicts a search window user-interface for defining search queries and filters;

Fig. **25** depicts a search window user-interface with an additional term search control;

Fig. **26** depicts a search window user-interface with the addition of a date range filter control;

Fig. **27** depicts a search window user-interface with the addition of a size range filter control;

Fig. **28** depicts a search window user-interface with the addition of a document type filter control;

Fig. **29** depicts a search window user-interface supporting multiple filters; and

Fig. **30** depicts a search window user-interface supporting multiple similar filters.

DETAILED DESCRIPTION

Aspects and embodiments of the present invention relate to a visual interface that harnesses human spatial memory for organizing and retrieving digital information. Software according to embodiments of the invention may provide a graphical user interface that allows a user to find and manage documents containing digital information. These documents may include, for example, any type of files (e.g., Microsoft Word documents, Microsoft Excel documents, Adobe PDF documents, formatted and unformatted text files, etc.), emails, contacts, calendar events, pictures and graphics files, music and audio files, movies and video files, web pages and web links, RSS files, and other forms of digital information. The files may be grouped by searches and may be represented on a two or three--dimensional information space, called an information map, as discussed further below. The information map may be used to manage the layout of and interaction with document references, as discussed further below. To facilitate spatial memory, the system may support persistent spatial mapping of the search results on the information map, such that the location of a reference to a document on the information map

does not move absent user intervention or specification, as discussed below. The information maps provide a unique and useful way to organize and manage large collections of digital information that may be used and shared by individuals, companies, groups of collaborators, and others.

One of ordinary skill will appreciate that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Examples of specific implementations are provided herein for illustrative purposes only and are not intended to be limiting. In particular, acts, elements and features discussed in connection with one embodiment are not intended to be excluded from a similar role in other embodiments. Also, the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," "having," "containing," or "involving," and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items.

According to one embodiment of the present invention, a graphical user interface is defined that supports the persistent spatial mapping of search results on a two-dimensional surface called an information map. Retrieved documents from a user-defined search are grouped together and placed within the two-dimensional information space and visually laid out using a parameterized algorithm, as discussed further below. Users may further refine the spatial position of individual document references via an adjustment to the parameterization algorithm. An image may be mapped to the two-dimensional surface defining a background upon which search nodes and individual document references may be positioned aiding in construction and

readability of the information map. Background images may include geographic maps, product schematics, diagrams, charts, calendars, photographs, artwork, or other two-dimensional imagery. Landmarks are specified as computed points on background images or information maps that may be used in aiding the computed or user-defined positioning of search nodes or individual document references. Landmarks are often specific and obvious special points on such background images. Individual information maps need not depict the entire universe of documents, but rather a subspace of information related to user-definable tasks. Multiple maps may be defined to capture different information spaces.

Search nodes may contain document references, which are references to the individual documents retrieved from a user-defined search. Document references are associated with digital information on a computer, including but not limited to, for example, formatted and unformatted text files, digital images, digital videos, audio files, e-mails, contacts, calendar events, web links, RSS feeds, and web pages. Document references contain information about the documents with which they are associated. For example, a document reference may specify the storage location on a computer or removable storage device of the associated document, the size of the document, creation and modification information (such as date, time, access, etc.) about the document. Information maps may support multiple references of the same document at different locations, thus allowing a document to be associated with multiple search nodes. The positions of document references within a search node are persistent and scalable subject to information space changes and user customization. Document references are updated to reflect the current state of the underlying system. For example, if a document on a computer is moved, all of its document references may be updated accordingly with the new location and modified date of the document. In another example, if a document is deleted, all its document references

may be updated to reflect the change and optionally, if the user requests, to keep a copy of the document available despite the deletion.

Search nodes may display all or subsets of individual document representations, summarization of all or subsets of documents, and the combination of individual document and summarized representations. Search nodes may be displayed using parameterized user-specified images in order to increase user recognition of the nodes content, including individual parameterized user's photos, company logo graphics, or any other standard digital image formatted content. Search nodes may be displayed as static or dynamic icons, including binders, shoeboxes, crates, cities, gardens, and numerous other physical or abstract imagery. Search nodes may be displayed as user-definable parameterized graphics and shapes, including standard parameterized geometric shapes, flow chart graphics, or other graphical objects. Search nodes may be displayed as more complex two- and three-dimensional, potentially summarizing, data-driven graphical objects based on the underlying collection of documents for the given search node including but not limited to: scatter plots, bar charts, pie charts, heatmaps, density plots, graphical signatures, point and line plots, graphical icons, and other data or information visualization techniques.

Information maps may be used as a visual front-end to arbitrary databases, beyond its initial application to document collections. Search nodes would then display database records that are not necessarily of the 'document' data type.

Information maps may be used to handle systems backup, beyond its initial application to document collections. Search nodes would then display and present differences from each previous backup representing states that are not necessarily of the 'document' data type.

Information maps maintain what are called the working references, those document references that are of importance to the user, specifically new document, documents that have yet to be read, documents with deadlines, documents that have priorities or ordering, or simply documents the user wants to be reminded about. Working references are visually distinguishable from the default document references, thus providing rapid feedback to the user when scanning an information map. Document references may be added to the set of working references in order to make them visually significant. Over time these working references change reflecting what the user has and is currently working on. Document references can be labeled or tagged using user-definable text to provide additional organization.

Information maps may also be shared with others, in the same way that ordinary geospatial maps are shared. Unlike the personal information maps, which have individual users customizing their own maps to fit their own view of their information; sharable information maps may have groups specify, define, collaborate, modify, and statically fix portions of their layout. Individuals working with a shareable map may be required to use the spatial layout of the common information map. One mechanism for defining a shared information map is to specify an image and landmarks common to all users. For instance, biologists working on the same organism might use an image of the organism as the background image and prescribe specific regions or landmarks for pieces of information. Biologists working with genes and a given gene expression pathway might use a static or dynamic image of the pathway for which they may share information by placing searches and results at landmarks on top of the pathway information map. Groups of users working on plans of a physical object, such as an engine, might use an overview mechanical drawing of the physical object as their background information map image and place searches at appropriate landmarks on the information map

related to the physical object. The use of shareable information maps is quite varied and may include group collaboration with minimal intervention. Users may quickly ascertain which documents are most important as they tend to be used more frequently. New documents in particular areas at specific landmarks might suggest that they need to be reviewed. Managers of groups may use these shareable information maps for tracking individual work and keeping up-to-date with group work. Access permissions may be either set by the owner of the original document or defined at group level control.

Embodiments of the present invention will hereinafter be described with references to the drawings, in which like numerals represent like elements throughout the several figures. Fig. **1** illustrates a computer architecture and operating environment. The operating environment includes a general purpose-computing device in the form of a personal computer or other such computing device **100**. Generally, the personal computer **100** includes one or more computer processing units (CPUs) **101**, an amount of computer memory **102**, one or more local or remote storage devices **103**, a graphics system **104** with at least one attached visual display **105**, one or more input devices **106,** and possibly attached output devices **107**, and optional network connectivity **108**, all internally connected via any of a variety of system buses **110**. In addition to the operating hardware **100**, the computing environment includes additional software, including the underlying operating system **109**, a graphical user interface **120**, one or more information indexing processes **111**, one or more information retrieval processes **112**, and one or more exemplary instances of the present invention information map, information map processes **113**. The indexing process **111** summarizes the stored documents on the attached local and remote storage devices **103** and maintains an index **114** of metadata about each document within a database or structured file store on the local storage device **103**. The retrieval process **112**

accesses documents indexed by the indexing process **111** from the index **114**, which are returned as a list of documents related to a user-defined search. The retrieval process **112** may also maintain a local cache **115** of additional information necessary for supporting interactions within the information map **113**. The information map process **113** communicates with the retrieval process **112** based on user-defined searches that are mapped within the graphical user interface **110** and rendered via the graphics system **104** and displayed on the visual display **105**. Users interact with the information map **113** using the input device **106**, enabling the positioning and editing of searches.

Fig. **2** is a block diagram illustration of the primary components of an embodiment of the present invention and defined by a software design **200**. The information map **113** is defined further by a number of connected components, such as for example the containing a map user-interface window **201**, a query component **202**, and a set of search plug-ins **203**. Each search plug-in **203** is defined by searcher component **204** that includes appropriate code for communicating with a specific data source **205**. The search plug-in may define the local cache **115** for storing retrieved documents and document properties. Individual data sources **205** contain stored data **206**, which a user requests to access, and may be on the same local computer or a remote networked computer as the information map process **113**. The data sources **205** may include an indexer component **207** for summarizing data **206** for optimizing content search, which is stored and maintained within an index **210**. The searcher component **204** communicates with the data source's **205** retrieval component **209** to access the data **206**. When the data source **205** provides the index **210**, the retrieval component **209** uses the index **210** to improve the searcher component **204** queries against the data **206**. The map user-interface window **201** of the information map **113** and its sub-components: (1) the map view control **210**,

(2) the search query control **211**, (3) a retrieval view control **212**, and (4) document filter controls **213**. The map view control **210** is the primary visual component for the information map **113**, which defines the graphics and interactions for constructing and modifying spatial information maps. The search query control **211** enables ad hoc term searching within the information map **113**. The retrieval view control **212** provides a standard list view of the documents returned from a search. The map filter controls **213** provide controls for defining dynamic queries enabling fast document filtering within the information map **113**.

Fig. **3** illustrates an exemplary map user-interface window **201**, including a map view control **210**, search query control **211**, and document filter controls **213**. Additionally, the map user-interface window **201** includes support for tabbed maps **300**, which may display related maps using the map's title or as a thumbnail image of the map.

Fig. **4** depicts an example of the map view control **210**. The map view control **210** is defined by a set of user-defined search nodes **400** that display graphical representations of documents, or document references **402**. The search nodes **400** may be defined by landmarks (see Fig. 5, 6, and 8) or anchors (see Fig. 7 and 8), both defined by one or more search criterion. Search nodes are associated with zero or more document references **401** that link to digital content stored on the local or a remote computer. A subset of the document references **401** are defined as working references **402** that may take on unique visual properties distinguishing them from other document references. Users may interact with the information map **113** and the map view control **210** using standard computer input devices **106**, which are represented as a graphic cursor **403** via the graphics user interface **110**. The default map view control **210** users' interaction for hovering the graphic cursor **403** over the document reference **401** or working

reference **402** is to display the document detail view **404**. The document detail view **404** includes a thumbnail image of the document and may or may not include a textual description.

The search nodes **400** (i.e., landmarks and anchors) are defined by zero or more search criteria, including search terms, date ranges, size ranges, document types, document properties, and data sources. Multiple search criteria may be combined using any logical operator. Further specification of operators may be made. For example, across multiple search nodes search criteria of the same type (i.e. date range, size range or document type) may be combined using the 'OR' logical operator, whereas while the combination search criteria of different type may be performed using the 'AND' logical operator.

The geometry of the search nodes **400** are defined by various parameters, which includes a center position on the two-dimensional map surface and a bounding region whose size may depict the number of the retrieved document references **401**. The graphical depiction of the individual search nodes **400** may be parameterized and customized to help users remember their content and importance, or to match the user's domain of expertise. The search nodes **400** may be visually displayed as parameterized representations of individual document references using standard icons, thumbnails, or other images. The search nodes **400** may be displayed using parameterized user-specified images in order to enhance user recognition of the nodes content, including individual parameterized user photos, company logo graphics, or any other standard digital image formatted content. The search nodes **400** may be displayed as static or dynamic icons, or glyphs, including binders, shoeboxes, crates, cities, gardens, and numerous other physical or abstract objects. The search nodes **400** may be displayed as user-definable parameterized graphics and shapes, including standard parameterized geometric shapes such as circles or rectangles, flow chart graphics, or any other graphical objects. The search nodes **400**

may be displayed as standard parameterized and customizable lists of documents. The search nodes **400** may also be opened to view their retrieved documents as parameterized scrollable lists of documents, which may be further organized and grouped by different document properties.

The search nodes **400** are associated with the document references **401**. The document references **401** are associated with digital information on the local computer or on the removable storage system or a remote computer, including for example formatted and unformatted text files, digital images, digital videos, audio files, e-mails, contacts, calendar events, web links and web pages. The present invention supports multiple document references **401** on the same information map linked to the same digital information, the document reference **401** located at different positions or at the same position within the two-dimensional surface. The positions of the document references **401** are persistent and scalable with a given information map, and are defined by a parameterization function, described next.

The layout of the document references **401** within a given map view control **210** of the information map **113** is computed using a parameterized positioning vector function with for example five supporting input parameters: (1) search landmarks **500**, (2) search anchors **700**, (3) document semantics, (4) local offset, and (5) local user customization. The search landmarks **500**, denoted by L, represent an image-based collection of points and regions defined by user or layout algorithms. The search landmarks **500** may be defined on an image, and provide a mechanism by which specific identifiable features in the underlying image may be incorporated in the visual positioning of the document references **401**. The search anchors **700**, denoted by A, represents a user-defined or algorithmically computed collection of points positioned independently of but relative to the underlying image. Document semantics, denoted by S, provides a mechanism by which users or algorithms may incorporate the positioning of

documents based on their semantics, providing for more complex filtering than simple Boolean operators. Local offset, denoted by *O*, represents a positioning adjustment defined by a user or algorithmically that permits overriding or influencing individual document positions and provides persistent visual separation between objects. Local user customization, denoted by *U*, provides a mechanism by which users may further refine the positioning of documents to increase their identification from other documents. Equation **1** is an example of a generalized document reference **401** positioning function, where $\alpha, \beta, \delta, \varphi, \mu \in [0, 1]$.

Equation **1** $$Pos(ref) = \alpha L(ref) + \beta A(ref) + \delta S(ref) + \varphi O(ref) + \mu U(ref)$$

The positioning of both the search landmarks **500** and the search anchors **700** are defined as an extension of radviz, a spring-force based visualization technique developed at the University of Massachusetts Lowell, Lowell, Massachusetts, U.S.A. Radviz positions objects based on a set of virtual springs connecting individual objects to dimensional anchors, an abstract representation of a data variable. Objects are pulled towards those dimensional anchors with higher dimensional weights placing the objects closer to the dimensional anchor locations, while moving objects further from dimensional anchor locations with lower dimension weights. *L* and *A* provide global or map-wide document reference **401** positioning variation. Equation **2** calculates the radviz vector position for the search landmarks **500** as a function of the rank or score of the document reference **401**. Equation **3** calculates the radviz vector position for the search anchors **700** as a function of the rank or score of the document reference **401**.

Equation **2** $$L(ref) = \sum_{Landmarks} ref * l_j \Big/ \sum_{Landmarks} ref$$

Equation **3** $$A(ref) = \sum_{Anchors} ref * a_j \Big/ \sum_{Anchors} ref$$

Fig. **5** depicts an example of the map view control **210** containing four search landmarks **500**. The search landmarks **500** are spatially dependent on the background image. The search landmarks **500** may be defined with a two-dimensional region **501**, which may be related to the background image. The search landmarks **500** may be defined by zero or more search criterion and may be associated with a set of zero or more document references **502**. The individual document references **401** associated to each search landmark **500** are positioned based on the parameterized positioning algorithm, previously described.

Fig. **6** depicts the map view control **210** containing two search landmarks **500** directly tied to a perspective image of a building **600**. The search landmark **500** is defined for the building's roof, and another search landmark **500** is defined for the door.

Fig. **7** depicts an example of the map view control **210** containing five search anchors **700**. Search anchors **700** are spatially independent of the background image but persistent and scalable relative to the map view control **210**. The search anchors **700** may be defined by one or more search criterion and may be associated with a set of zero or more document references **701**. The individual document references **401** associated with each search anchor **700** are positioned based on the parameterized positioning algorithm, previously described.

Fig. **8** depicts an example of the map view control **210** combining four search landmarks **500** and three search anchors **700**. The document references **401** associated with each search landmark **500** and search anchor **700** are positioned based on the parameterized positioning algorithm. The set of document references **401** for search anchors **700**, **800** that fall within one

or more search landmark regions **501** are reduced to include those documents that also map to document references **401** associated with each associated search landmark **500**.

Fig. **9** depicts an example of a map view control **210** containing a search landmark **500** and a search anchor **700**. The document references **401** of the search landmark **500** and search anchor **700** may be positioned based on variations of the parameterized positioning algorithm. The search landmark **500** displays for example three document references **401, 900** above the label for 'new' documents, and displays five document references **401** for the five most related documents. The search anchor **700** displays three groups of document references **401, 901** using a circular arrangement. This positioning of the document references 401 is performed by the parameterized positioning algorithm.

Fig. **10** depicts an example of the map view control **210** containing the same search landmark **500** and search anchor **700** from Fig. **9**. Users may customize the spatial placement of the individual document references **401, 1000** to provide additional visual significance to important documents. This customization of the spatial placement is handled by the parameterized document reference **401** positioning algorithm.

Fig. **11** depicts graphical representations of document references **401** as grouped together to define the search nodes **400**. The document references **401** may be displayed using graphical objects **1100**, icons **1101**, or thumbnail images **1102**. The document references **401** displayed using standard graphical objects **1100** may be drawn using squares, circles, triangles, stars, and so forth using different interior colors and textures, and assorted bounding line colors and styles. The document references **401** displayed using the icons **1101** may be drawn using a single custom icon, custom icons for different document types, or standard system icons provided by the underlying operating system **109**. The document references **401** displayed using the

thumbnail images **1102** may be drawn as a reduced thumbnail image of the whole document, as a page of the document, as an image contained within the document, or represented by a custom image provided by the user.

Fig. **12** depicts potential thumbnail representations of the working references **402** as compared with their surrounding document references **401** using the different graphical representations: the graphical objects **1100**, the icons **1101**, and the thumbnail images **1102**. The main intent of the working references **402** is their visual distinction from the document references **401**; consequently, it is advantageous to display working references **402** using unique visual properties. Two approaches for displaying the working references **402** include standard document thumbnails **402** at a slightly larger size than the document references **401**, or as document thumbnails with borders **1200**. Color and animation may also be used.

Fig. **13** illustrates an example of potential document reference **401** mouse interactions with thumbnail popups **1400, 1401** and thumbnail popups with textual details **1402, 1403**. The document references **401** and the working references **402** respond to mouse-over and mouse-hover interactions by displaying medium thumbnail popups **1400** or large thumbnail popups **1401** without document information, and medium thumbnail popups with document details **1402** or large thumbnail popups with attached document details **1403**.

Fig. **14** depicts an example of the drag-and-drop user interaction for positioning search nodes **400**. As individual document references **401** and working references **402** are already defined with drag-and-drop functionality, the search nodes **400** (e.g., search landmarks 500 and search anchors 700) are controlled and manipulated via their representation graphics. Users mouse-down on individual search node representation graphic with the attached input devices **106** and represented by the graphic cursor **403**, then users drag-and-drop the selected search node

representation graphics along an interaction curve **1400** to position the search node **400** at a new location **1401**.

Fig. **15** depicts selection of the search nodes **400** and the graphical representations of the related document references **401** and the working references **402**. Users selected a search node **400a** by a mouse click on the search node's representation graphics with the attached input devices **106** and represented by the graphic cursor **403**. Search node **400a** may include appropriate graphics for indicating that the search nodes **400a** has been selected, including changing the background color, fill textures, bounding curve color, and associated other visual properties **1500**. Furthermore, the document references **401** and the working references **402** of the selected search node **400a**, the selected references **1501**, may also take on custom graphics to distinguish them from the unselected document references **1504**. Since the document references **401** and working references **402** are associated with actual document and other pieces of information, the document references **401** and working references **402** associated with selected documents also become selected references **1501** taking on the same distinguishing graphics. Search nodes **400c** with mixed selected and unselected document reference **401** and the working references **402** appear different to the selected nodes **400a**, while the search nodes **400b** with no selected document references **401** or working references **402** appear as normal.

Fig. **16** depicts an example of the drag-and-drop user interaction applied to the selected document references **401, 1501** and the working references **402, 1501** between two search nodes **400a** and **400b**. The document references **401** and the working references **403** within search nodes **400a** may be selected by user mouse-click events with the attached input devices **106** and represented by the graphic cursor **403**. The selected references **1501** are then dragged across the map view control **210** along a user-defined path **1600** to a destination node **400b**. During transit,

the selected references **1501** may take on custom graphical attributes to distinguish them from other document references **401** and the working references **402** not selected. The selected references **1501** are dropped within a second destination node **400b** and added to the destination node's **400b** list of related documents. The addition of the selected references **1501** to a destination node **400b** may for example be performed by adding the destination node's **400b** key terms to the documents referenced by the selected references **1501** or by customizing the list of document references **401** and working references **402** maintained by the destination node **400b**.

Fig. **17** depicts an example of the drag-and-drop user interaction applied to selected document references **401, 1501** and the working references **402, 1501** between an existing search node **400a** and the defining of a new search node **400b**. The document references **401** and working references **402** within the search nodes **400a** may be selected by user mouse-click events with the attached input devices **106** and represented by the graphic cursor **403**. The selected references **1501** are then dragged across the map view control **210** along a user-defined path **1700** to a destination location **1702** defining a new search node **400b** for the selected references **1501**. During transit, the selected references **1501** may take on custom graphical attributes. The new search node **400b** is defined by the most interesting terms and phrases common between the selected references **1501**.

Fig. **18** depicts the drag-and-drop user interaction applied to importing documents **1801** placed onto an information map **201** into an existing search node **400**. The documents **1801** are those graphical representations of documents defined outside of the information map **201** by the operating system **109** within the surrounding desktop environment **1800**. The documents **1801** may be selected by user mouse-click events with the attached input devices **106** and represented by the graphic cursor **403**. The documents **1801** are then dragged on to the information map **201**

and across the map view control **210** along a user-defined path **1802** to a destination node **400**. The documents **1801** are dropped within an existing destination node **400** and added to the destination node's **400** list of related documents by defining new document references **401** and working references **402** for the selected documents **1801**. The addition of the documents **1801** to a destination node **400** may be performed for example by adding the destination node's **400** key terms to the documents metadata maintain within the corpus **115** or by customizing the list of document references **401** and the working references **402** maintained by the destination node **400**.

Fig. **19** depicts an example of the drag-and-drop user interaction applied to importing documents **1801** placed onto an information map **201** defining new search nodes **400**. The documents **1801** are those graphical representations of documents defined outside of the information map **201** by the operating system **109** within the surrounding desktop environment **1800**. The documents **1801** may be selected by user mouse-click events with the attached input devices **106** and represented by the graphic cursor **403**. The documents **1801** are then dragged into the information map **201** and across the map view control **210** along a user-defined path **1900** to a destination location **1901**. New document references **401** and working references **402** are defined for the selected documents **1801** and used to define the new search node **400**. The new search node **400** is defined by the most interesting terms and phrases common between the new document references **401** and working references **402**.

Fig. **20** depicts an example of the drag-and-drop user interaction applied to exporting selected document references **1501** out of the information map **201** on to the desktop environment **1800**. The document references **401** and the working references **402** within the search nodes **400** may be selected by user mouse-click events with the attached input devices

106 and represented by the graphic cursor **403**. The selected references **1501** are then dragged across the map view control **210** and out of the information map **201** along a user-defined path **2000** on to the surrounding desktop environment **1800**. On mouse release the selected references **1501** are converted to their associated documents and pasted as documents **1801** to the appropriate location within the operating system's **109** desktop environment **1800**.

Fig. **21** depicts an example of the drag-and-drop user interaction applied to importing folders **2100** placed onto an information map **201** defining new search nodes **400**. The folders **210** are those graphical representations of document sets defined outside of the information map **201** by the operating system **109** within the surrounding desktop environment **1800**. The folders **2100** may be selected by user mouse events with the attached input devices **106** and represented by the graphic cursor **403**. The folders **2100** are then dragged into the information map **201** and across the map view control **210** along a user-defined path **2101** to a destination location **2100**. New document references **401** and working references **402** are defined for the documents **1801** contained with the selected folders **2100** and used to define the new search node **400**. The new search node **400** is defined by the most interesting terms and phrases common between the new document references **401** and working references **402**.

Fig. **22** depicts an example of the drag-and-drop user interaction applied to exporting search nodes **400** out of the information map **201** on to the desktop environment **1800**. The search nodes **400** are selected by user mouse-clicks with the attached input devices **106** and represented by a graphic cursor **403**. Search nodes **400** may include appropriate graphics for indicating that the search nodes **400** have been selected, including background color and textures, and bounding curve color and styles **1500**. Furthermore, the document references **401** and working references **402** of the selected search node **400**, the selected references **1501**, may

also take on custom graphics to distinguish them from other unselected document references **401** and working references **402**. The search node is then dragged across the map view control **210** and out of the information map **201** along a user-defined path **2200** on to the surrounding desktop environment **1800**. On mouse release the document references **401** and working references **402** of the selected nodes **400** are converted to their associated documents and pasted as system documents **1801** within a newly defined system folder **2100** labeled with the search nodes' **400** label within the appropriate location in the operating system's **109** desktop environment **1800**.

Fig. **23** depicts an example of the general search of related documents via the search query control **209**. The search query control **209** specifies a search for all documents related to "visualization". The map view control **210** responds to search query control **209** changes and selects those document references **401** and working references **402** associated with related documents, the selected reference **1501**. The selected references **1501** may take on custom graphics to distinguish them from unselected document references **401** and working references **402**.

Fig. 24 depicts an example of a search window user-interface **2400** for defining search queries and attaching document filters. The search window **2400** is an example of a search query control **209**. The search window **2400** includes a search text field **2401** for entering terms against which the related information map **113** is searched and document references highlighted. Furthermore, the search window **2400** displays the number of retrieved documents via the document counter **2402**. Finally, the search window **2400** provides a document filter control **2403** for adding one or more document filter controls **213** via the document filter popup menu **2404**, which is currently illustrating four types of document filters: terms, dates, sizes, and types.

Fig. **25** depicts an example of a search window user-interface **2400** with an additional term filter control **2500**, an instance of a document filter control **213**. The term filter control **2500** includes a remove filter button **2501** used to remove the filter from the current search window **2400**.

Fig. **26** depicts an example of a search window user-interface **2400** with the addition of a date range filter control **2600**, an instance of a document filter control **213**. The date range filter control also includes a remove filter button **2601** used to remove the filter from the current search window **2400**. Furthermore, date range filter controls **2600** include a list of defined date ranges **2602**: any date, within the last week, within the past month, within the year, and a custom date range. The label of the date range filter control **2600** depicts the selected date range **2602**. The date range filter control **2600** also includes a minimized view **2603**, which displays the control as a button from which the details of the date range filter control **2600** may be accessed.

Fig. **27** depicts an example of a search window user-interface **2400** with the addition of a size range filter control **2700**, an instance of a document filter control **213**. The size range filter control also includes a remove filter button **2701** used to remove the filter from the current search window **2400**. Furthermore, size range filter controls **2700** include a list of defined size ranges **2702**: any size, small, medium, large, and a custom size. The label of the size range filter control **2700** depicts the selected size range **2702**. The size range filter control **2700** also includes a minimized view **2703**, which displays the control as a button from which the details of the size range filter control **2700** may be accessed.

Fig. **28** depicts an example of a search window user-interface **2400** with the addition of a type filter control **2800**, an instance of a document filter control **213**. The type filter control also includes a remove filter button **2801** used to remove the filter from the current search window

2400. Furthermore, the type filter controls **2800** include a tree view of user-definable document type categories **2802** shown here to include documents, images, movies, and music. The label of the type filter control **2800** depicts the selected document types **2802**. The type filter control **2800** also includes a minimized view **2803**, which displays the control as a button from which the details of the type filter control **2800** may be accessed.

Fig. **29** depicts an example of a search window user-interface **2400** applying two document filter controls **213**, specifically a size range filter control **2700** and a type filter control **2800**. Fig. **29A** has a minimized size range filter control **2703** with an open type filter control **2800**, which has only image types selected in the type category tree view **2802**. The search window user-interface **2400** in this instance restricts only one document filter control **213** being opened at any one time. When the user clicks on the minimized size range filter control **2703** the search window user-interface **2400** changes to Fig. **29B**, which displays the open size range filter control **2700**, the list of defined size ranges **2702**, and a minimized type filter control **2803**.

Fig. **30** depicts a search window user-interface **2400** applying multiple similar document filter controls **213**, specifically two size range filter controls **2700a/b** and a term filter control **2500**. Fig. **11A** illustrates a search for "visualization" and "exploration" as shown in the search term field **2401a** and to include only small size documents or large size documents via the two size range filter controls **2700a** and **2700b**, respectively. The number of documents retrieved for this previous search is 1638 documents, indicated by the document counter **2402a**. Fig. **11B** illustrates a search for "visualization" as shown in the search term field **2401b** and to include only small size documents and large size documents via the two size range filter controls **2700a** and **2700b**, respectively, plus an additional term filter control **2500** to include additional documents with the term "exploration". This search query retrieves 1686 documents, indicated

by the document counter **2402b**. Similar multiple document filter controls **213** are applied via the logical operator "OR".

Aspects and embodiments of the present invention thus provide a visual interface to large collections of digital information. Advantageously, the invention may assist users by providing a graphical user interface designed to harness human spatial memory for organizing and retrieving digital information. Information maps according to embodiments of the invention may provide an interface for the spatial organization of digital information within a two-dimensional space with rapid visual feedback and information access. As discussed above, the present invention may support persistent state information whereby search nodes and document references are spatially fixed so that users may harness their spatial memory to organize and find information quickly. In addition to the graphical user interface, the underlying software architecture may support different search engines via a dynamically loaded plug-in mechanism.

Having thus described several aspects and embodiments of the invention, modifications and/or improvements may be apparent to those skilled in the art and are intended to be part of this disclosure. It is to be appreciated that the invention is not limited to the specific examples described herein and that the principles of the invention may be used in a wide variety of applications and may be programmed using a variety of different software platforms. The above description is therefore by way of example only, and includes any modifications and improvements that may be apparent to one skilled in the art.

Although the present invention has been shown and described with respect to several preferred embodiments thereof, various changes, omissions and additions to the form and detail thereof, may be made therein, without departing from the spirit and scope of the invention.

What is claimed is:

1. A drag-and-drop user interface for organizing, managing, and working with information, comprising:

a spatial surface upon which landmarks and search nodes are placed embodied by a map view control;

a list of landmarks containing a user-defined persistent search spatially positioned on the surface with zero or more area defined by some shape;

a list of search nodes containing a user-defined persistent search spatially positioned on the surface; and

a document reference relating documents to spatial positions on the surface relative to associated landmarks and search nodes; and

a working reference or marked document reference associated with system provided or user-defined categorical labels or tags.

2. The drag-and-drop interface of claim **1**, wherein the position of search nodes are customizable by users for personal spatial recognition.

3. The drag-and-drop interface of claim **1**, wherein the position of document references and working references are customizable by users for personal spatial recognition with search nodes.

4. The drag-and-drop interface of claim **1**, where the spatial surface comprises a two-dimensional surface.

5. A drag-and-drop user interface for organizing, managing, and working with information, comprising:

a two-dimensional surface upon which search nodes are placed embodied by a map view control;

a list of search nodes containing the set of user-defined persistent searches spatially positioned on the two-dimensional surface;

a document reference relating documents to spatial positions on the two-dimensional surfaces relative to associated search nodes; and

a working reference relating certain documents to spatial positions on the two-dimensional surfaces relative to associated search nodes.

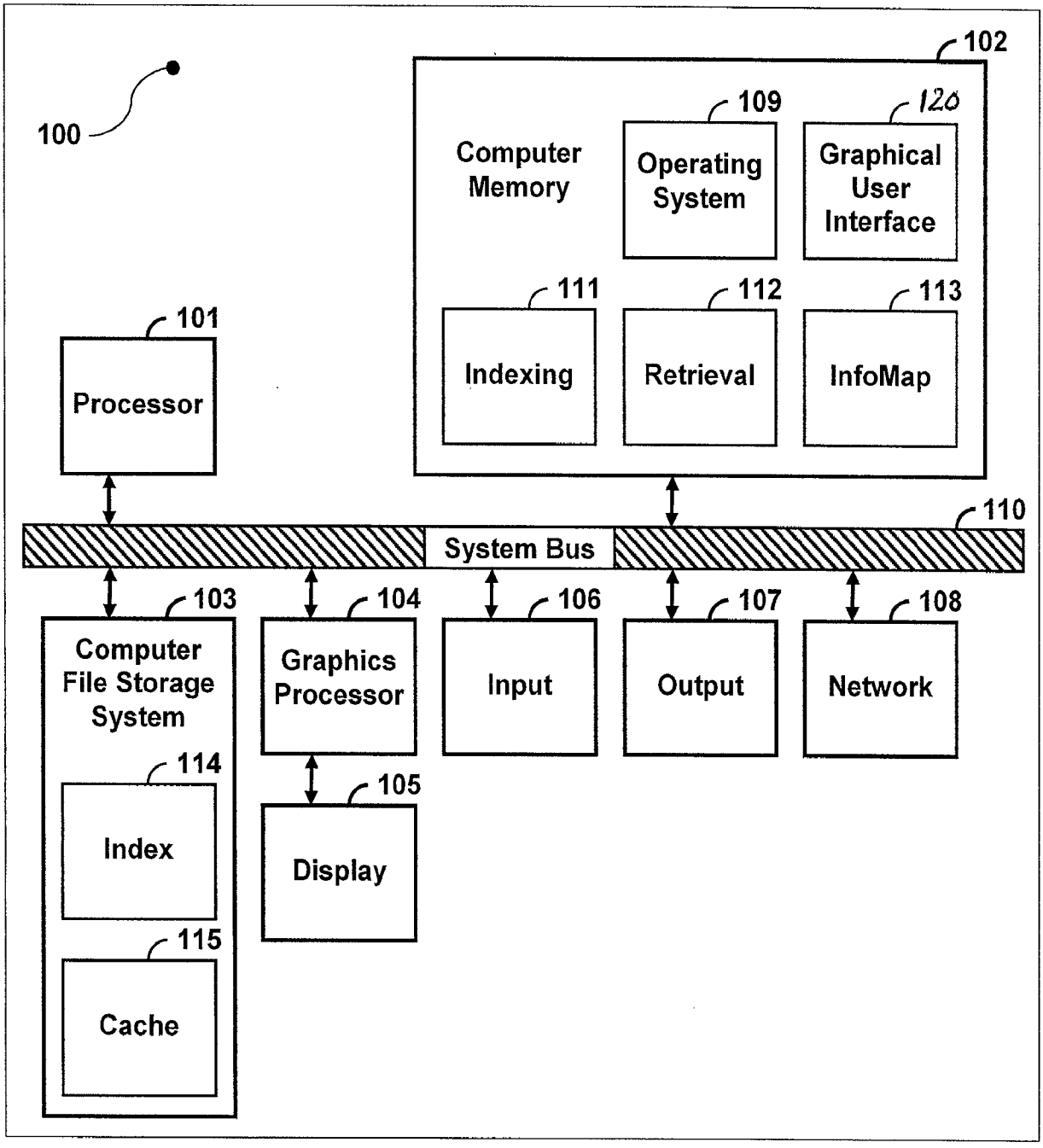

100
102
Computer Memory
109
Operating System
120
Graphical User Interface
111
Indexing
112
Retrieval
113
InfoMap
101
Processor
110
System Bus
103
Computer File Storage System
114
Index
115
Cache
104
Graphics Processor
105
Display
106
Input
107
Output
108
Network

Fig. 1

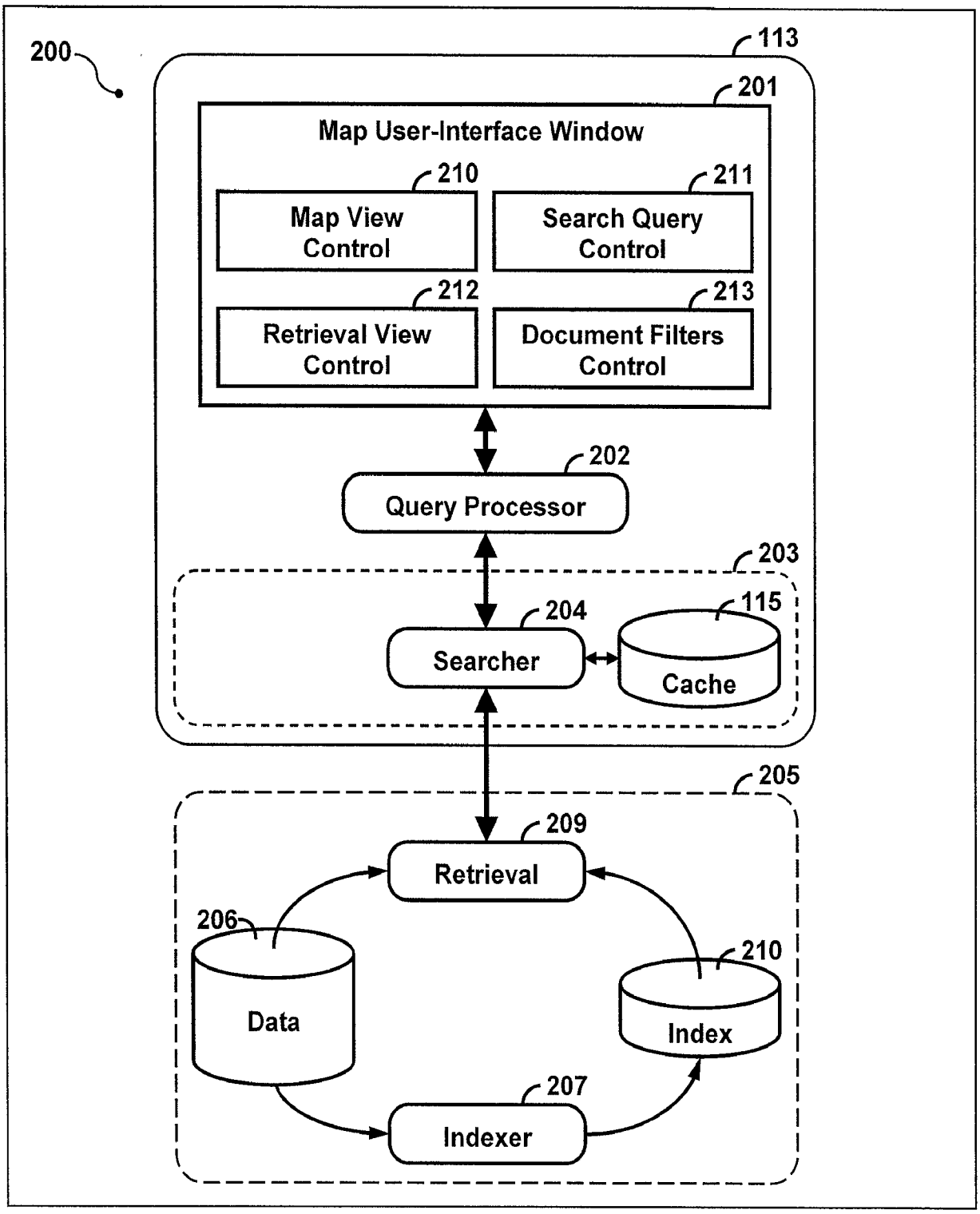

200
113
201
Map User-Interface Window
210
Map View Control
211
Search Query Control
212
Retrieval View Control
213
Document Filters Control
202
Query Processor
203
204
Searcher
115
Cache
205
209
Retrieval
206
Data
210
Index
207
Indexer

Fig. 2

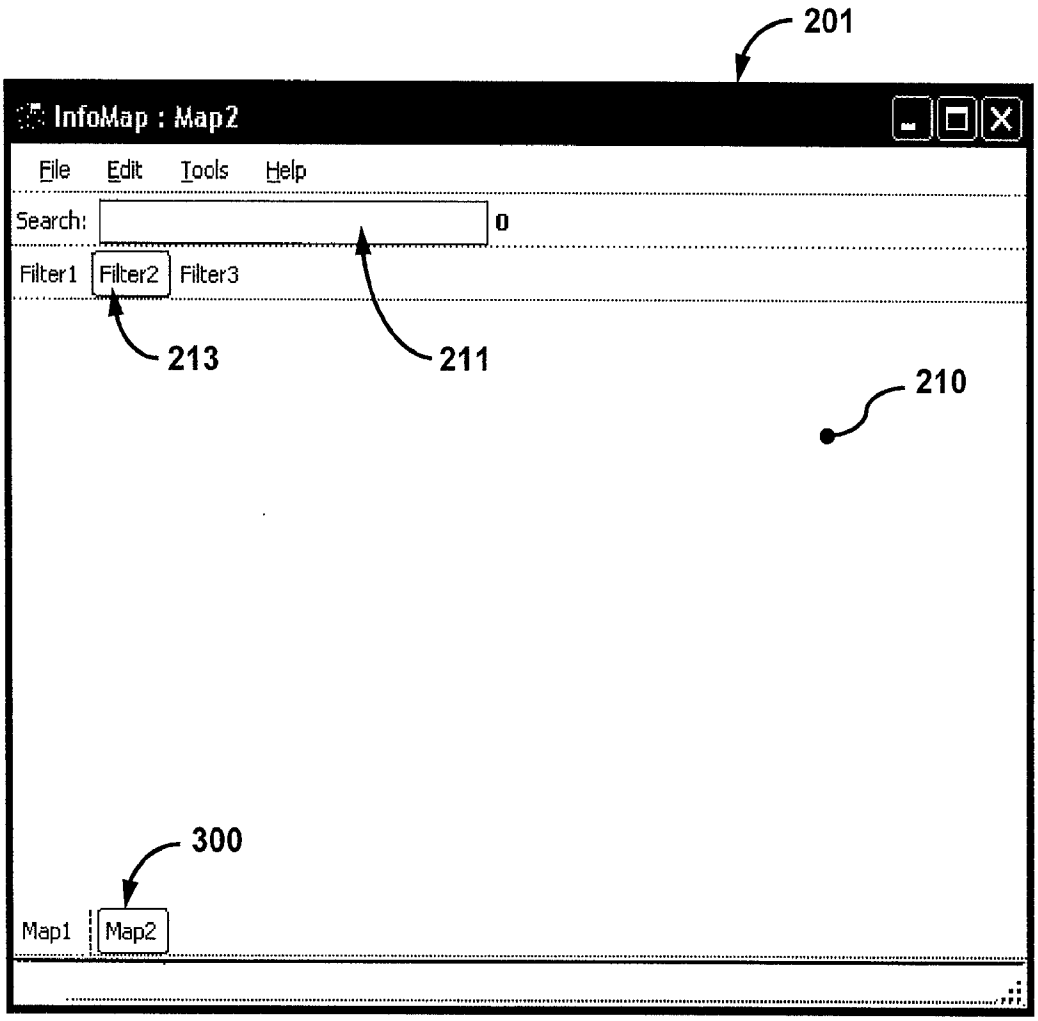

201
InfoMap : Map2
File
Edit
Tools
Help
Search:
0
Filter1
Filter2
Filter3
213
211
210
300
Map1
Map2

Fig. 3

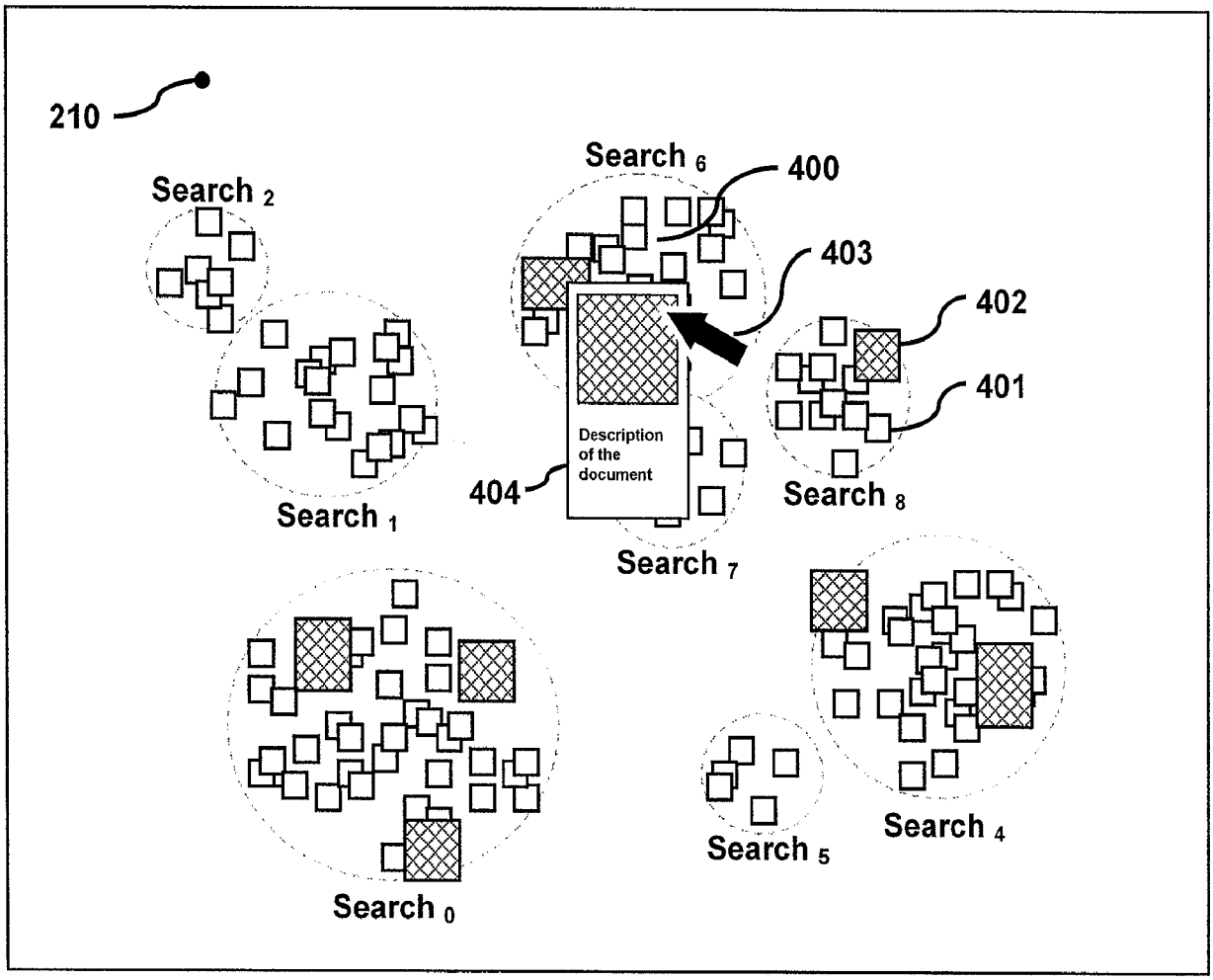

210
Search 2
Search 6
400
403
402
401
Description of the document
404
Search 1
Search 8
Search 7
Search 0
Search 5
Search 4

Fig. 4

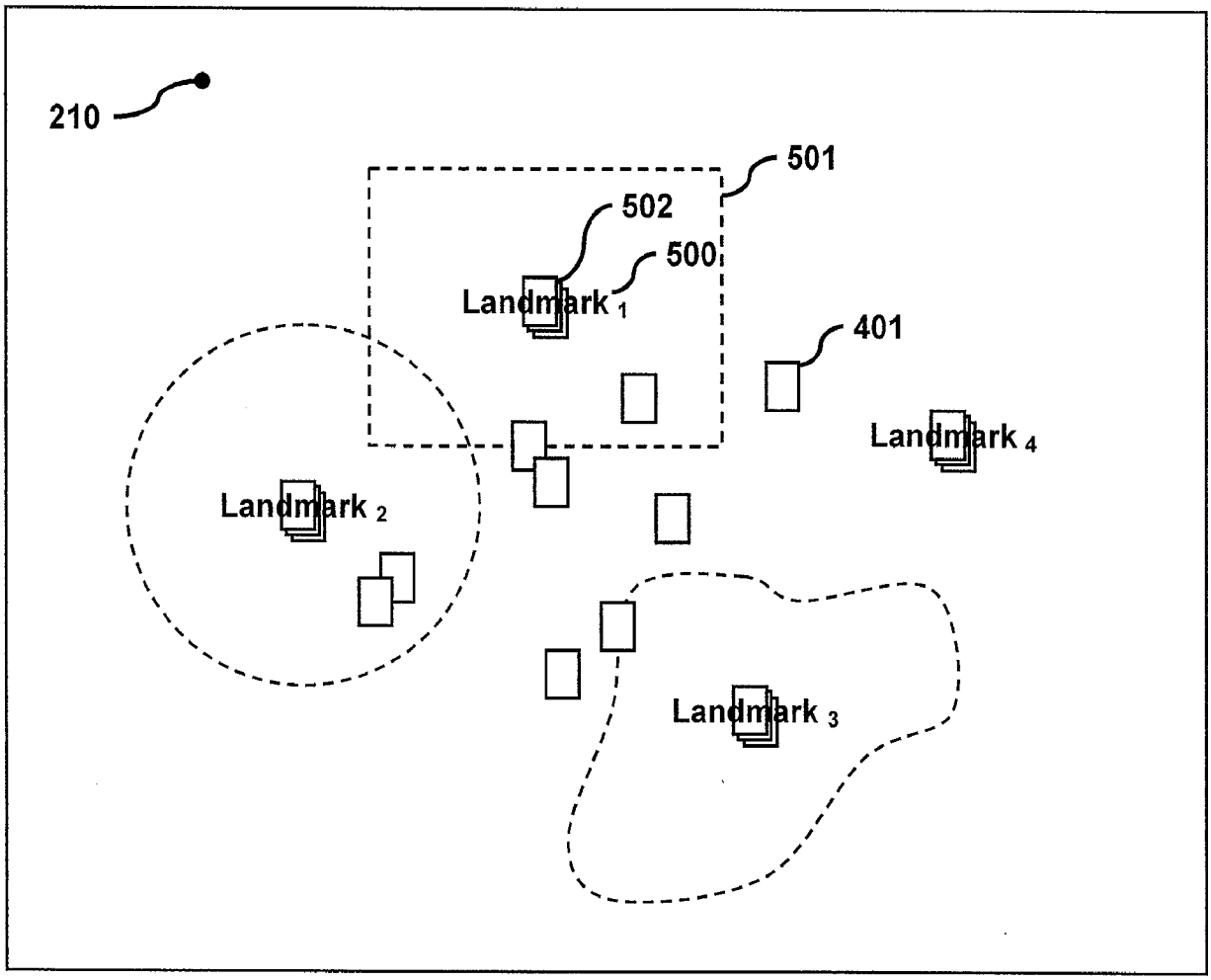

210
501
502
500
Landmark 1
401
Landmark 4
Landmark 2
Landmark 3

Fig. 5

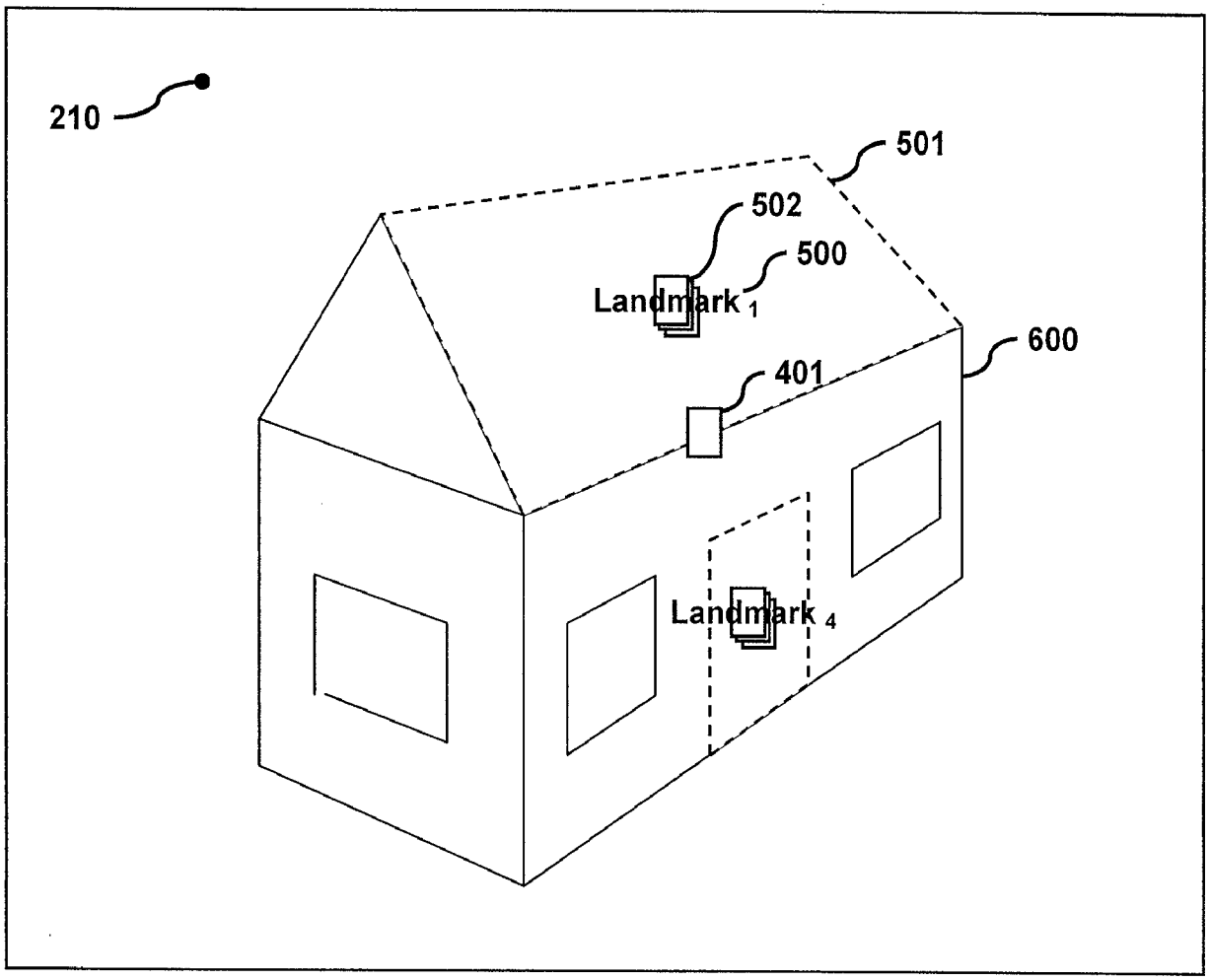


Fig. 6

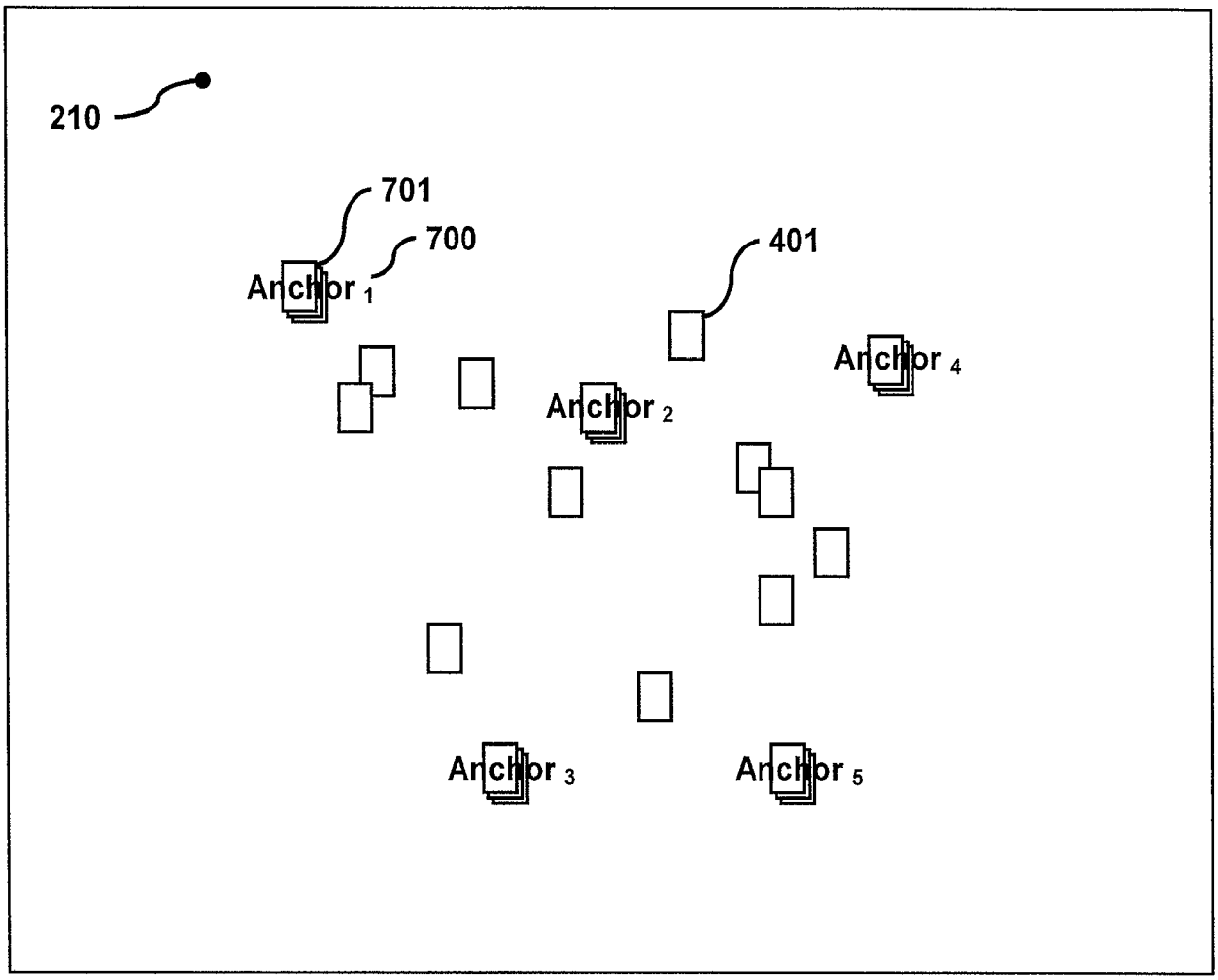


Fig. 7

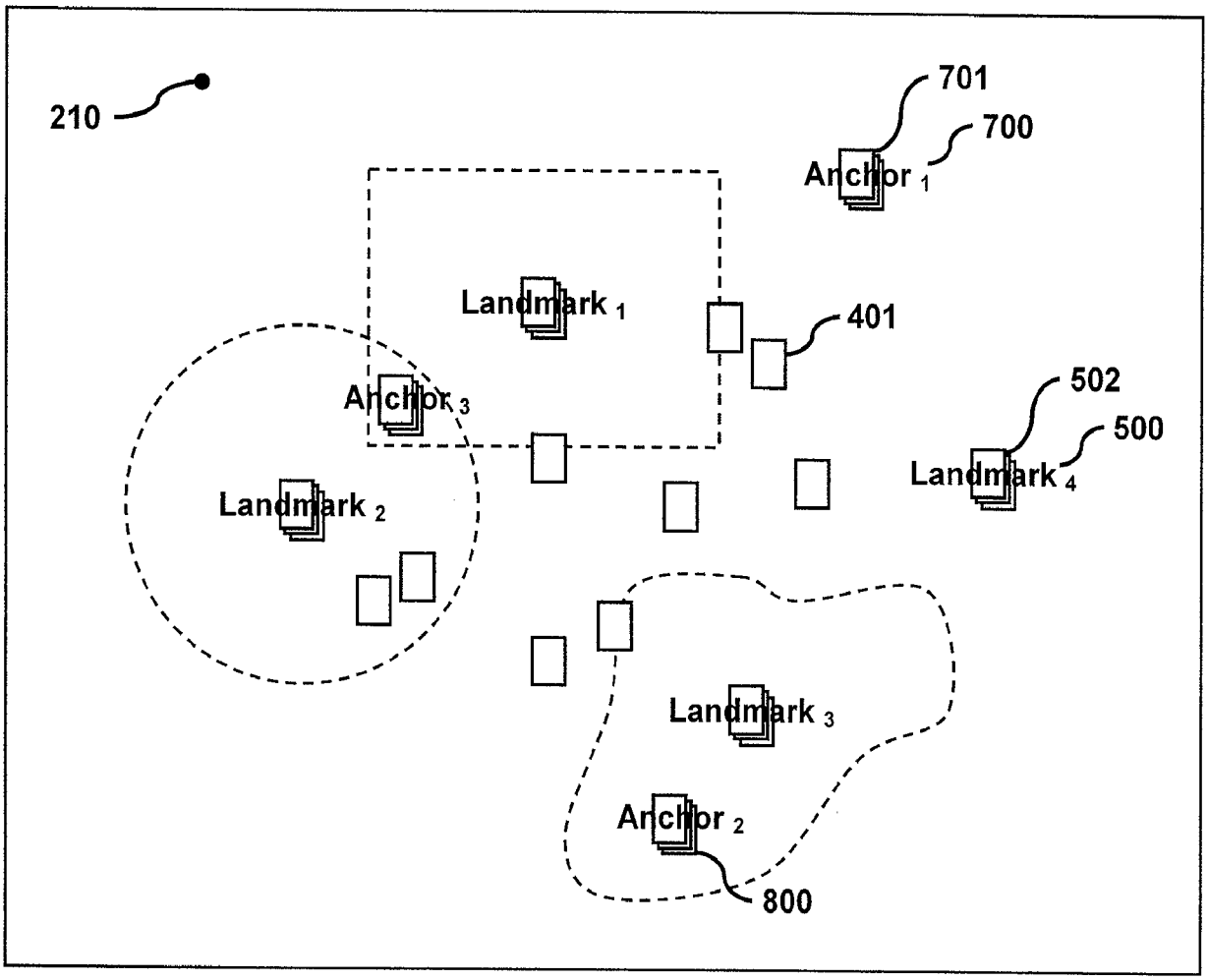

210
701
700
Anchor 1
Landmark 1
401
Anchor 3
502
500
Landmark 4
Landmark 2
Landmark 3
Anchor 2
800

Fig. 8

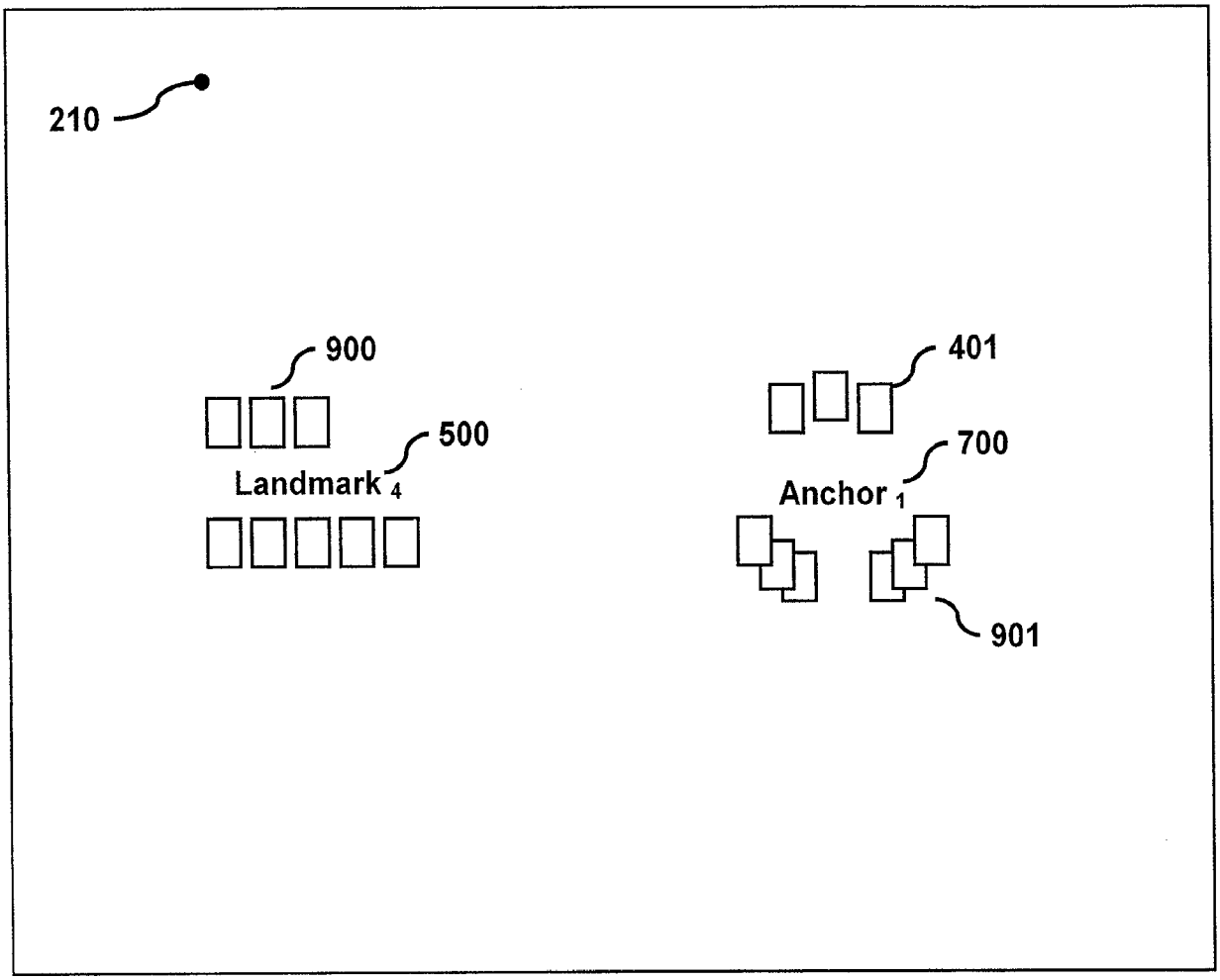


Fig. 9

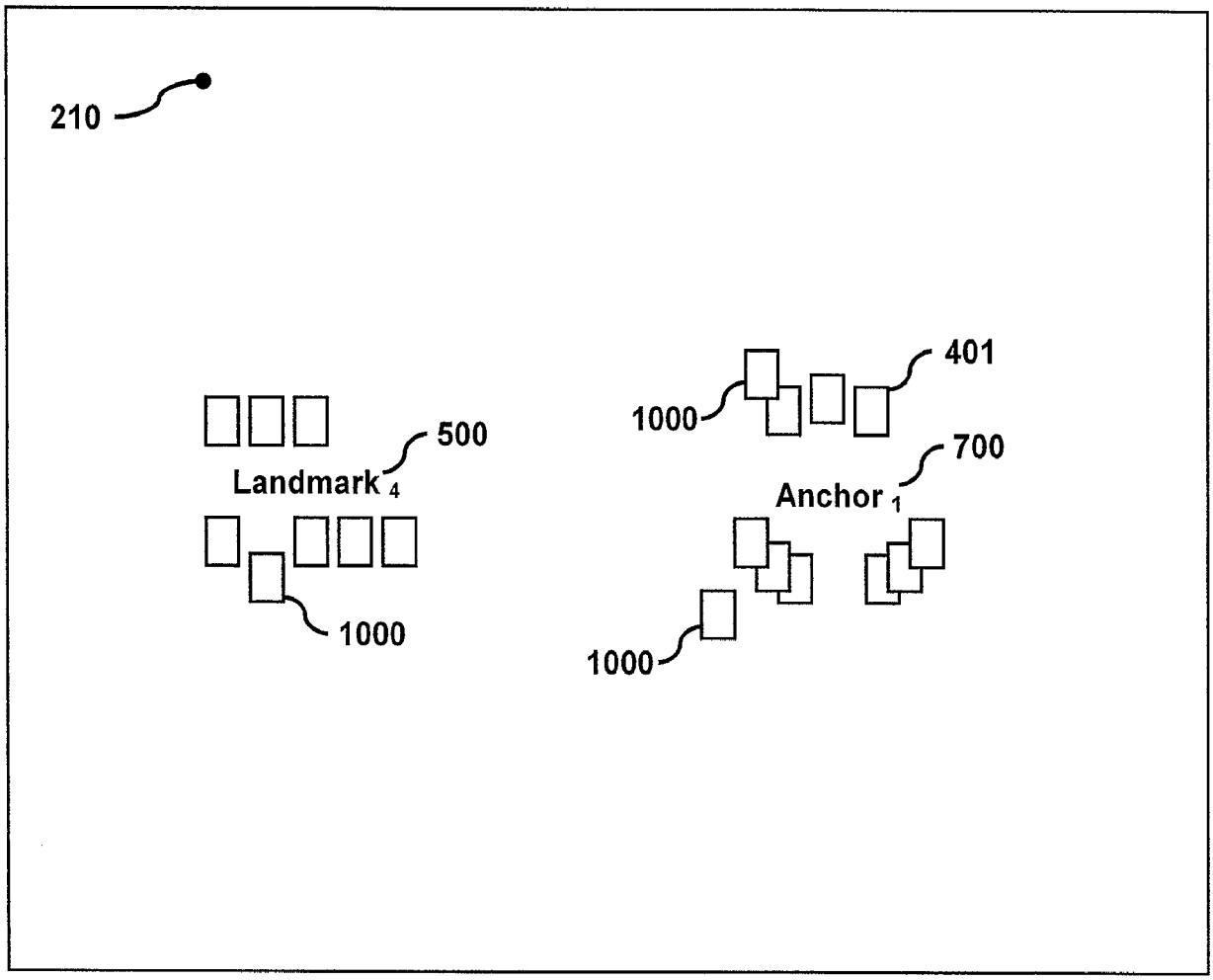


Fig. 10

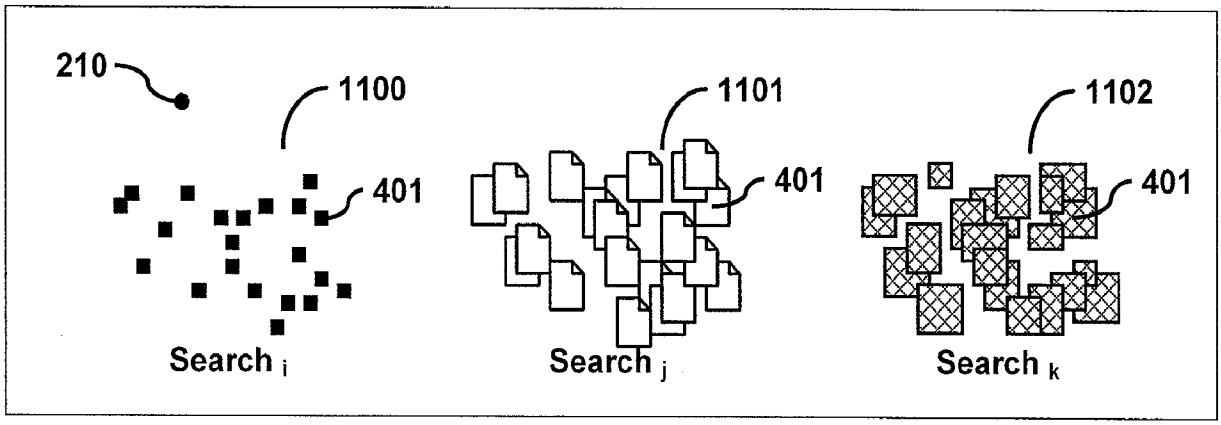


Fig. 11

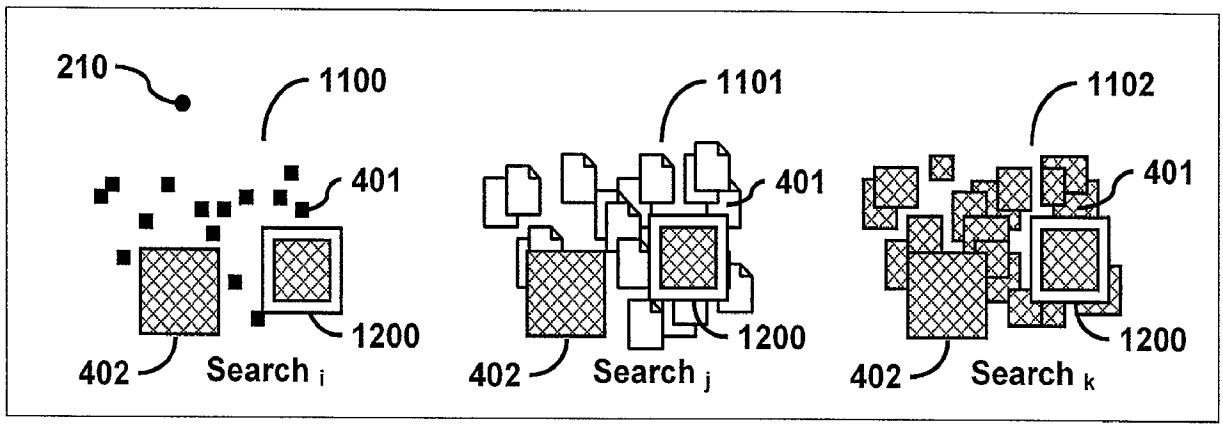

210
1100
401
1200
402
Search i
1101
401
1200
402
Search j
1102
401
1200
402
Search k

Fig. 12

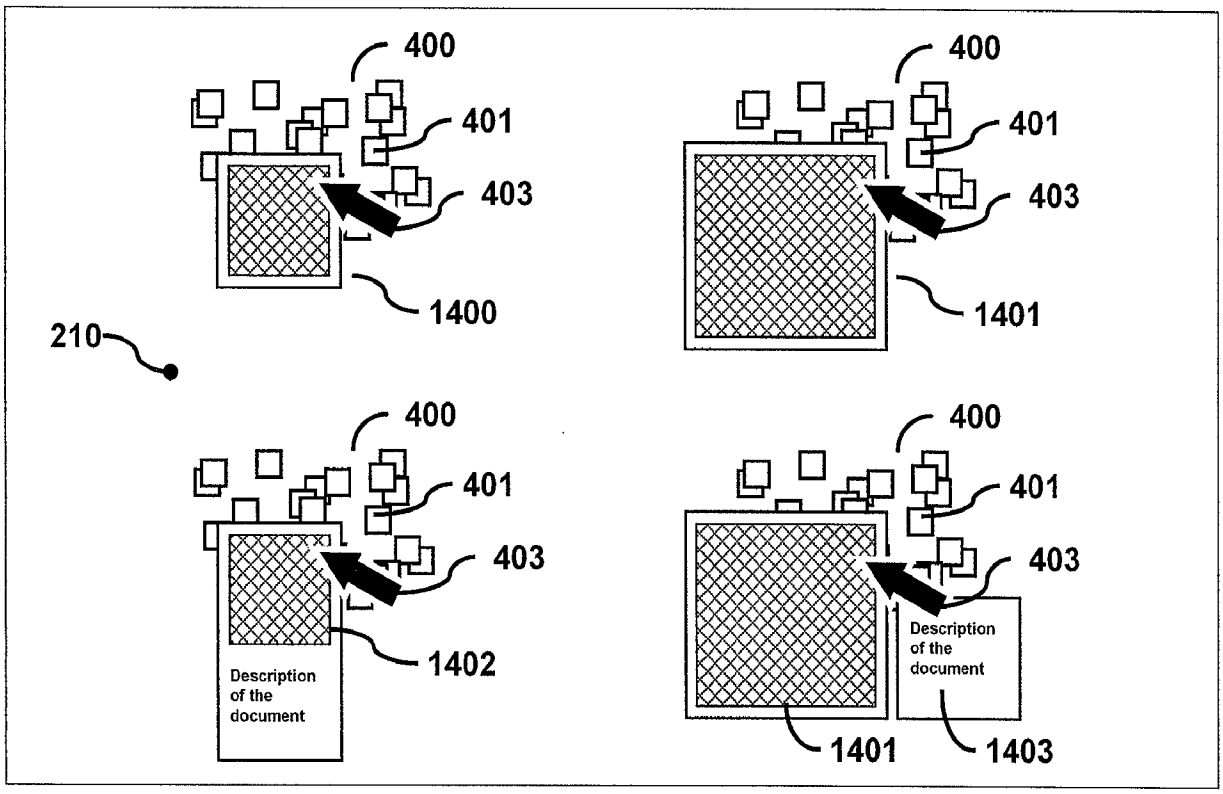

400
401
403
1400
210
400
401
403
1401
400
401
403
1402
Description of the document
400
401
403
Description of the document
1401
1403

Fig. 13

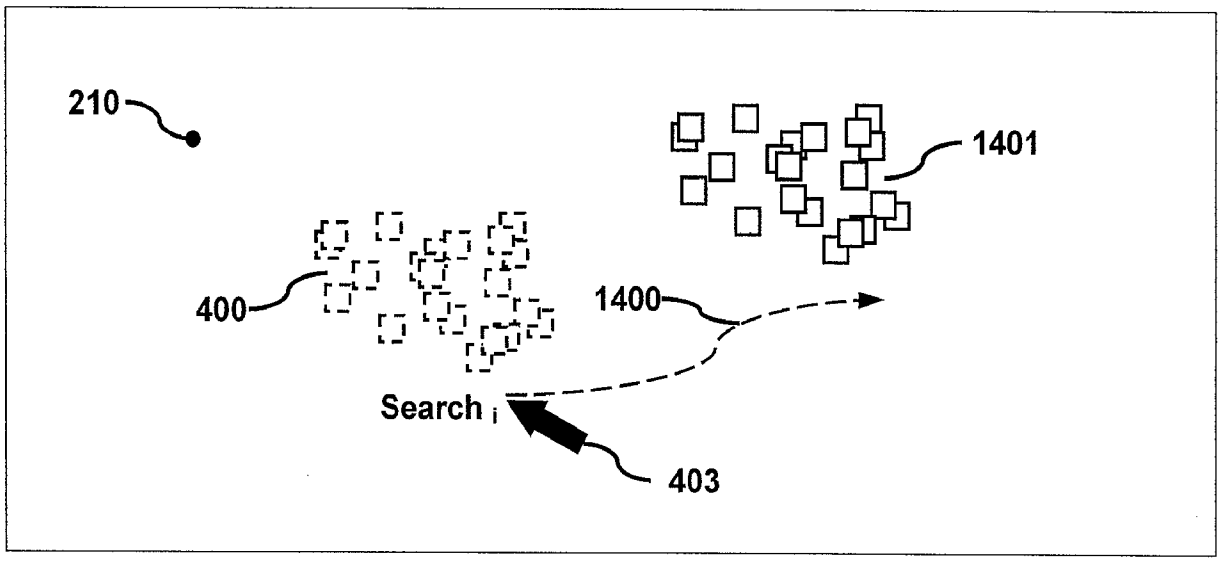


Fig. 14

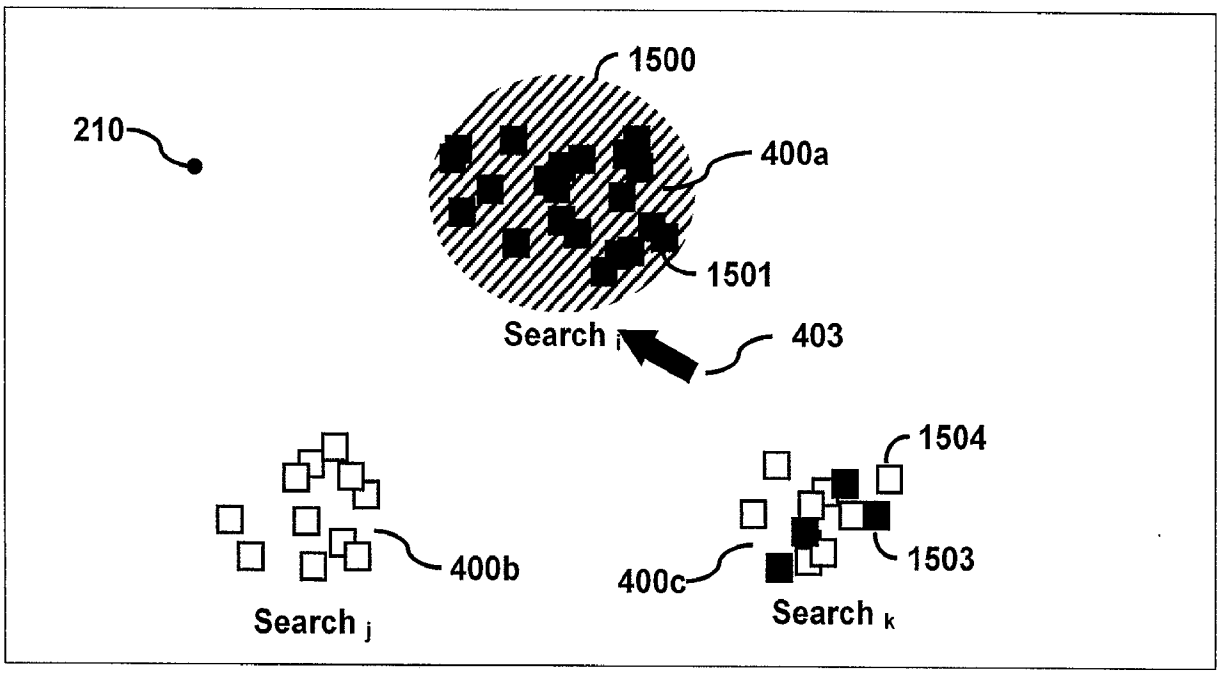

1500
210
400a
1501
Search i
403
1504
400b
1503
400c
Search j
Search k

Fig. 15

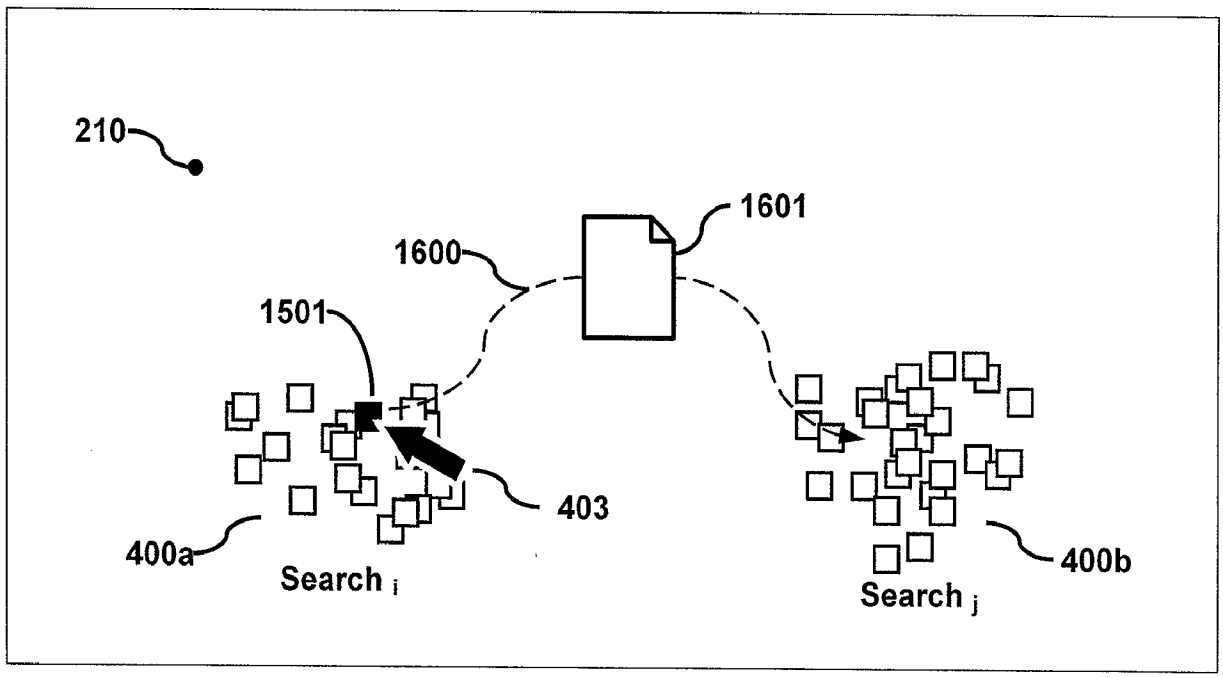


Fig. 16

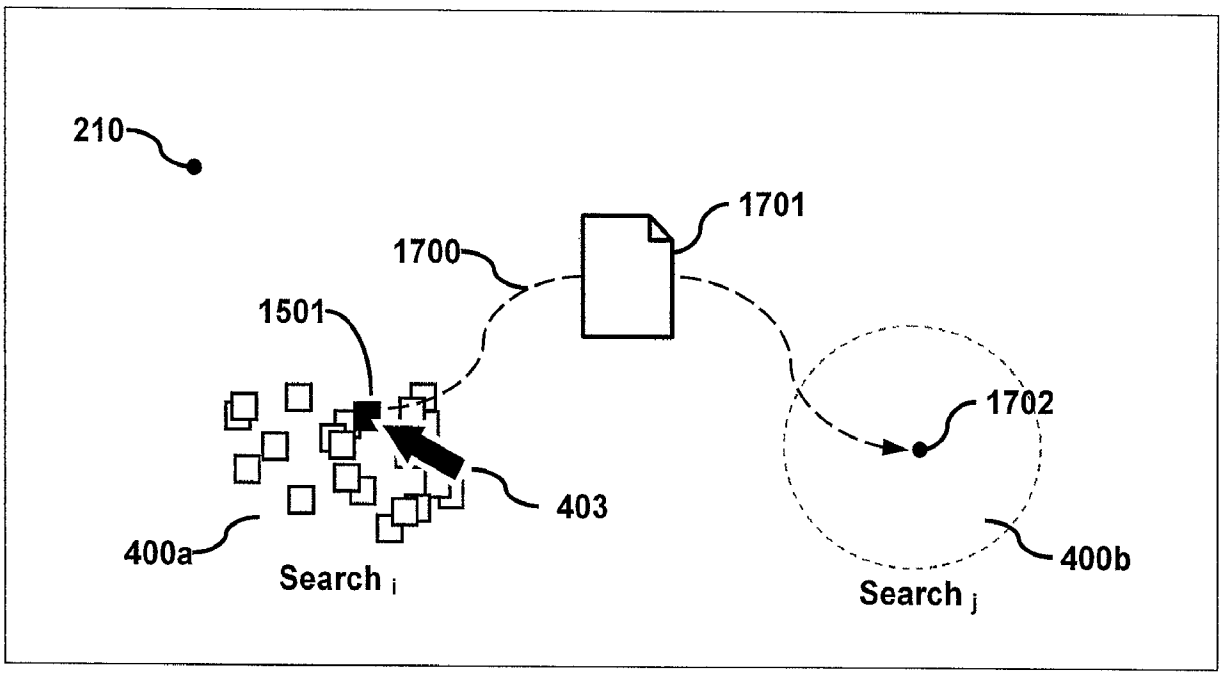


Fig. 17

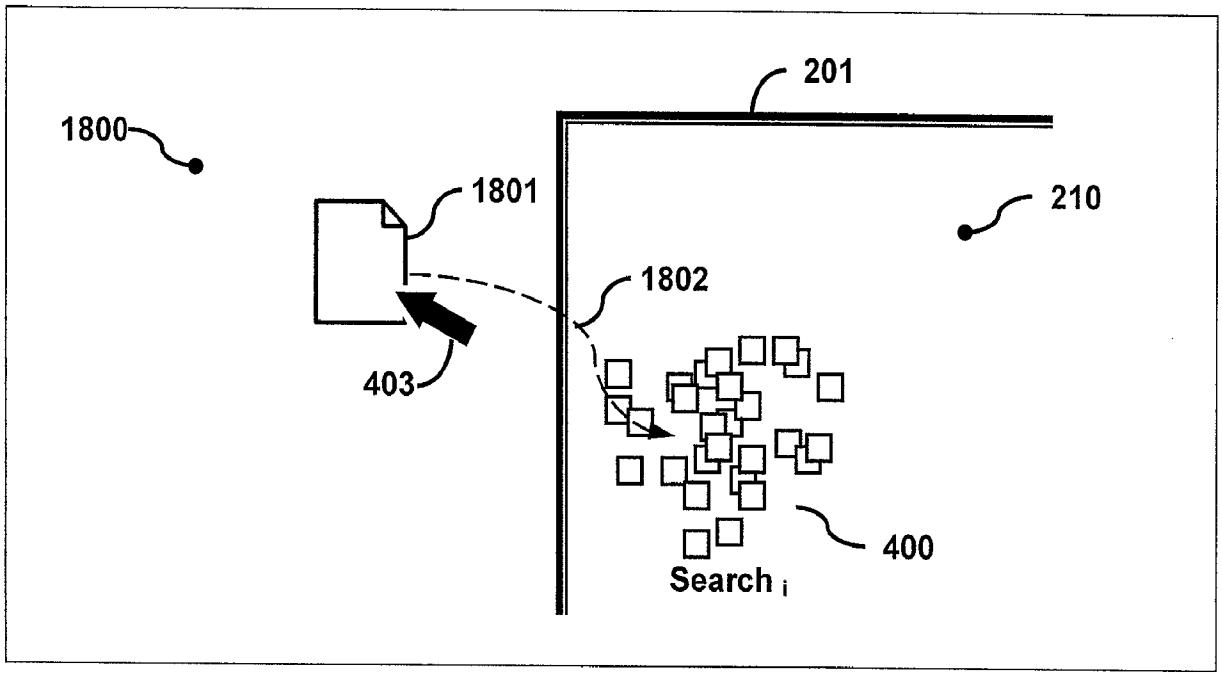


Fig. 18

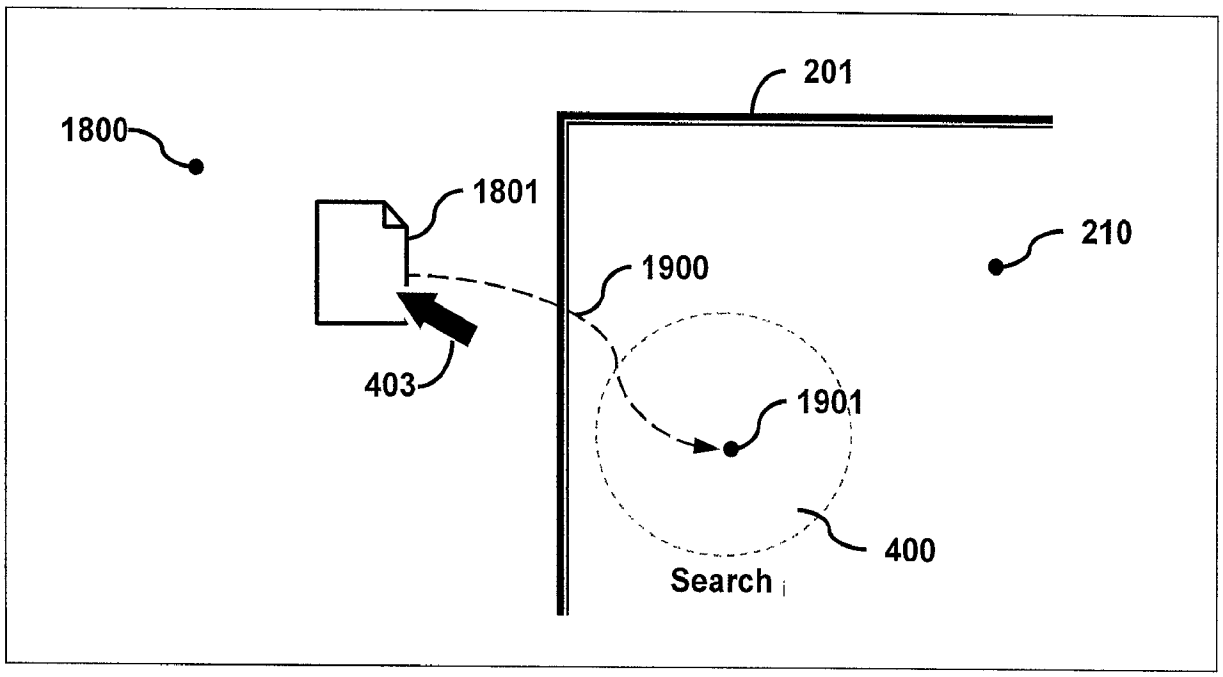


Fig. 19

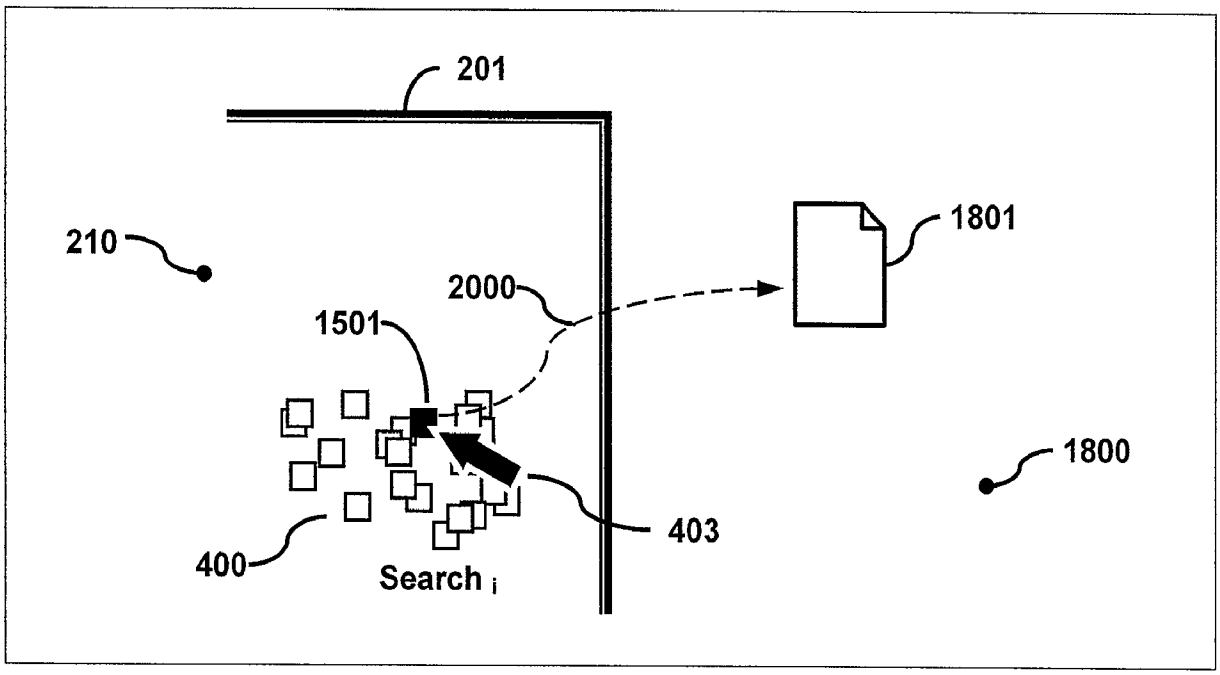


Fig. 20

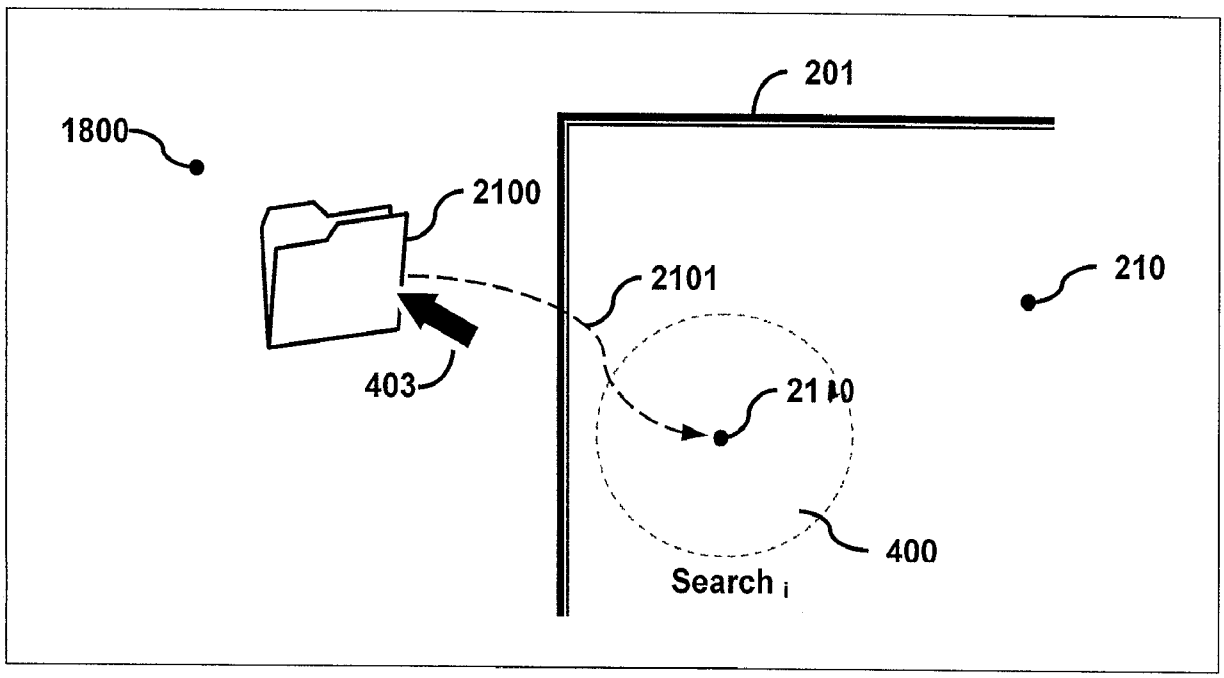


Fig. 21

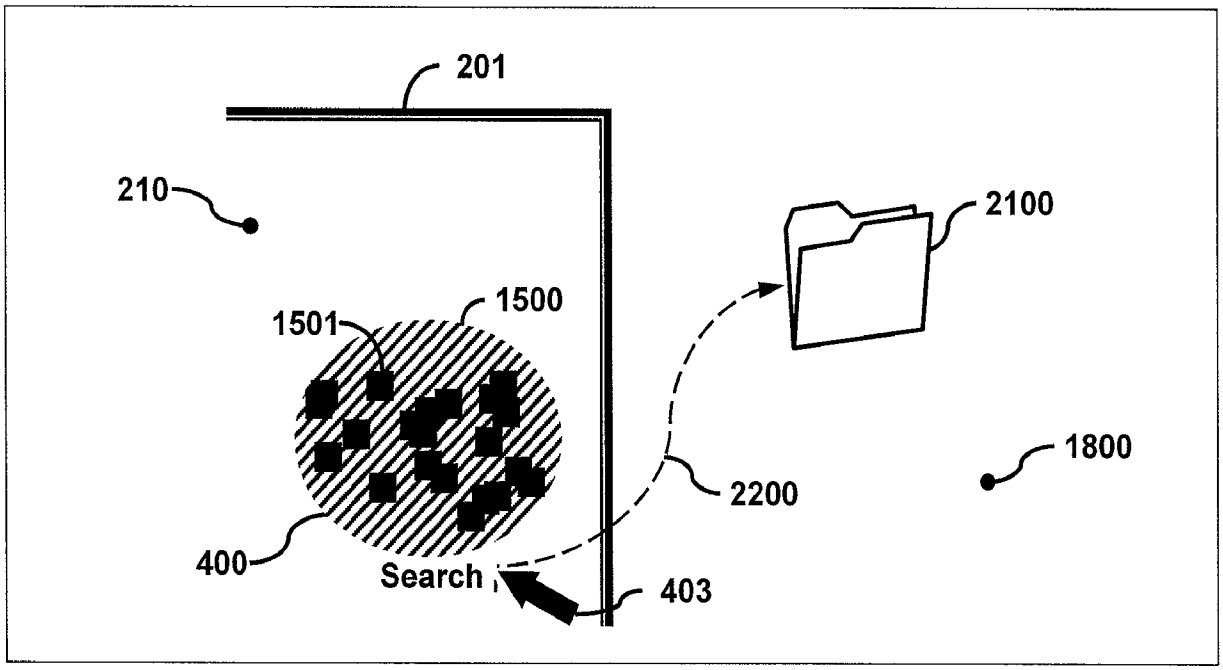


Fig. 22

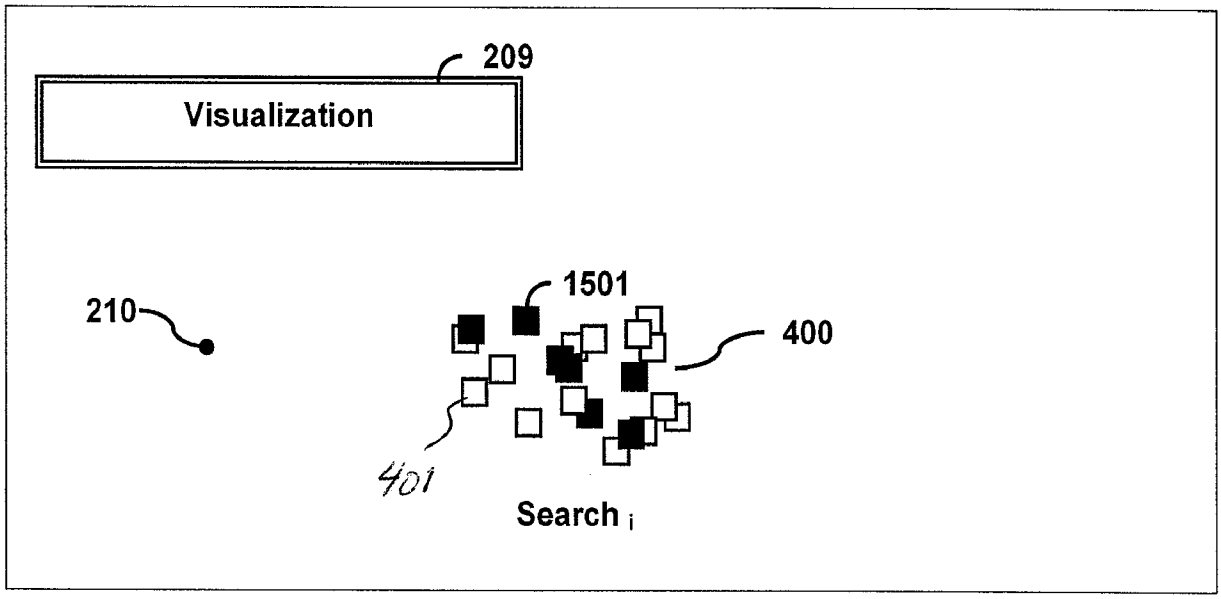


Fig. 23

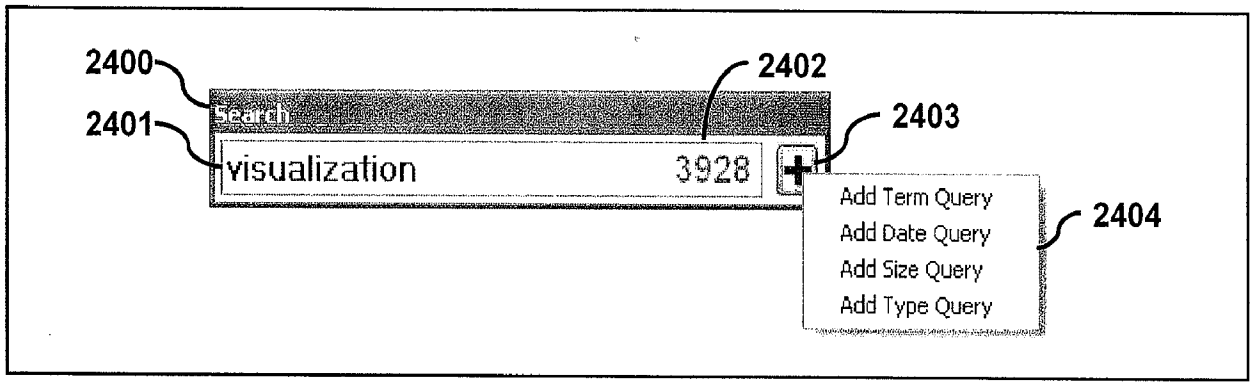

2400
2401
2402
2403
2404
Search
visualization
3928
Add Term Query
Add Date Query
Add Size Query
Add Type Query

Fig. 24

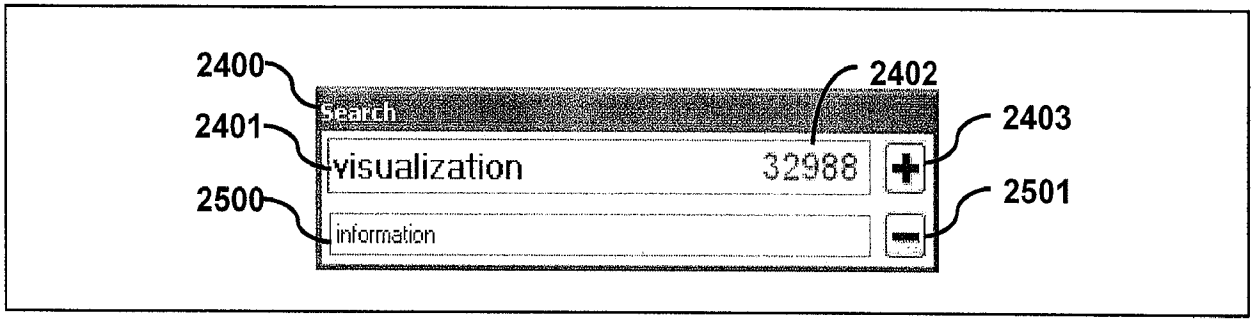

2400
2401
2500
2402
2403
2501
Search
visualization
32988
information

Fig. 25

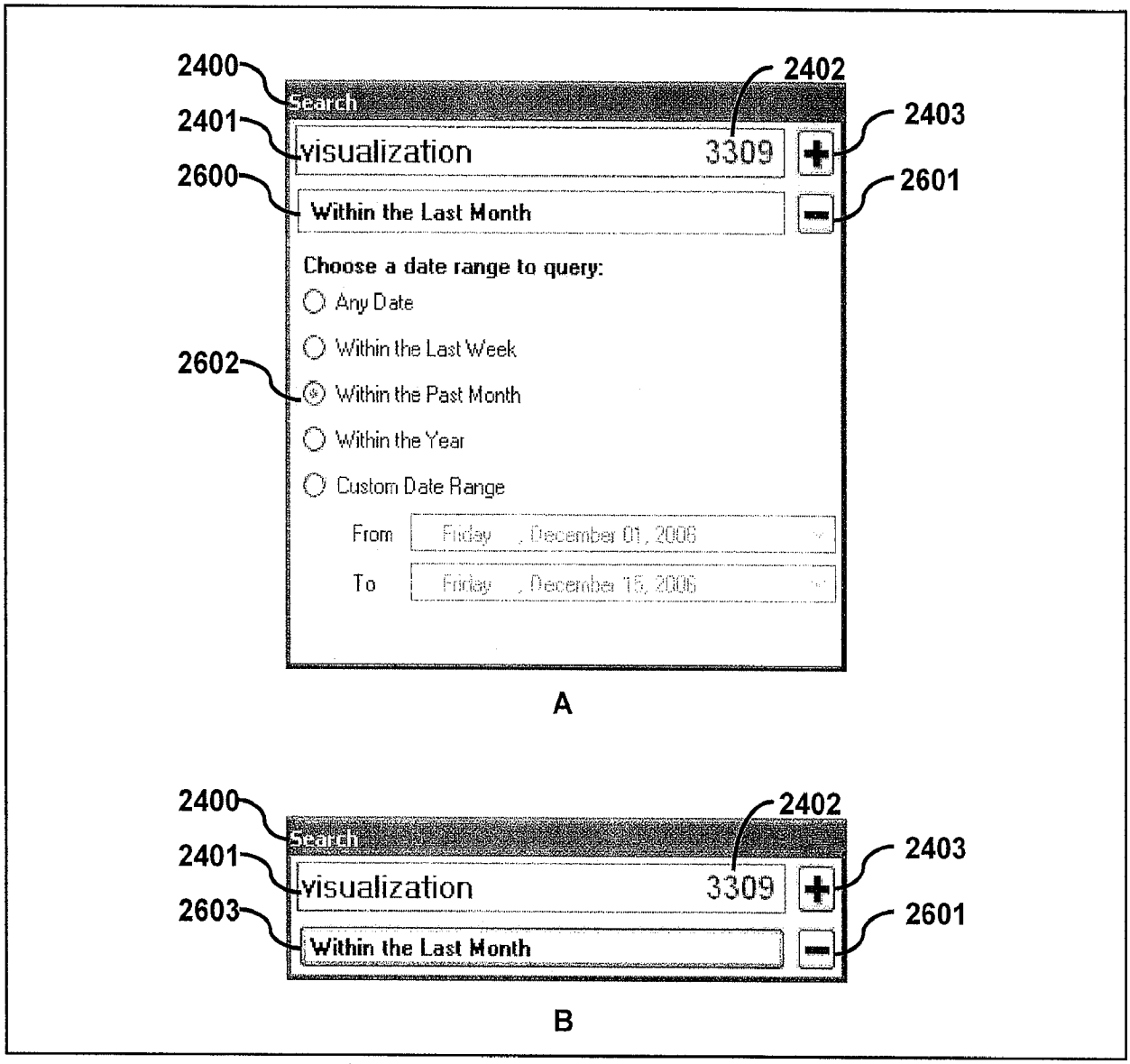

2400
2401
2600
2602
2402
2403
2601
Search
visualization
3309
Within the Last Month
Choose a date range to query:
Any Date
Within the Last Week
Within the Past Month
Within the Year
Custom Date Range
From
To
A
2400
2401
2603
2402
2403
2601
Search
visualization
3309
Within the Last Month
B

Fig. 26

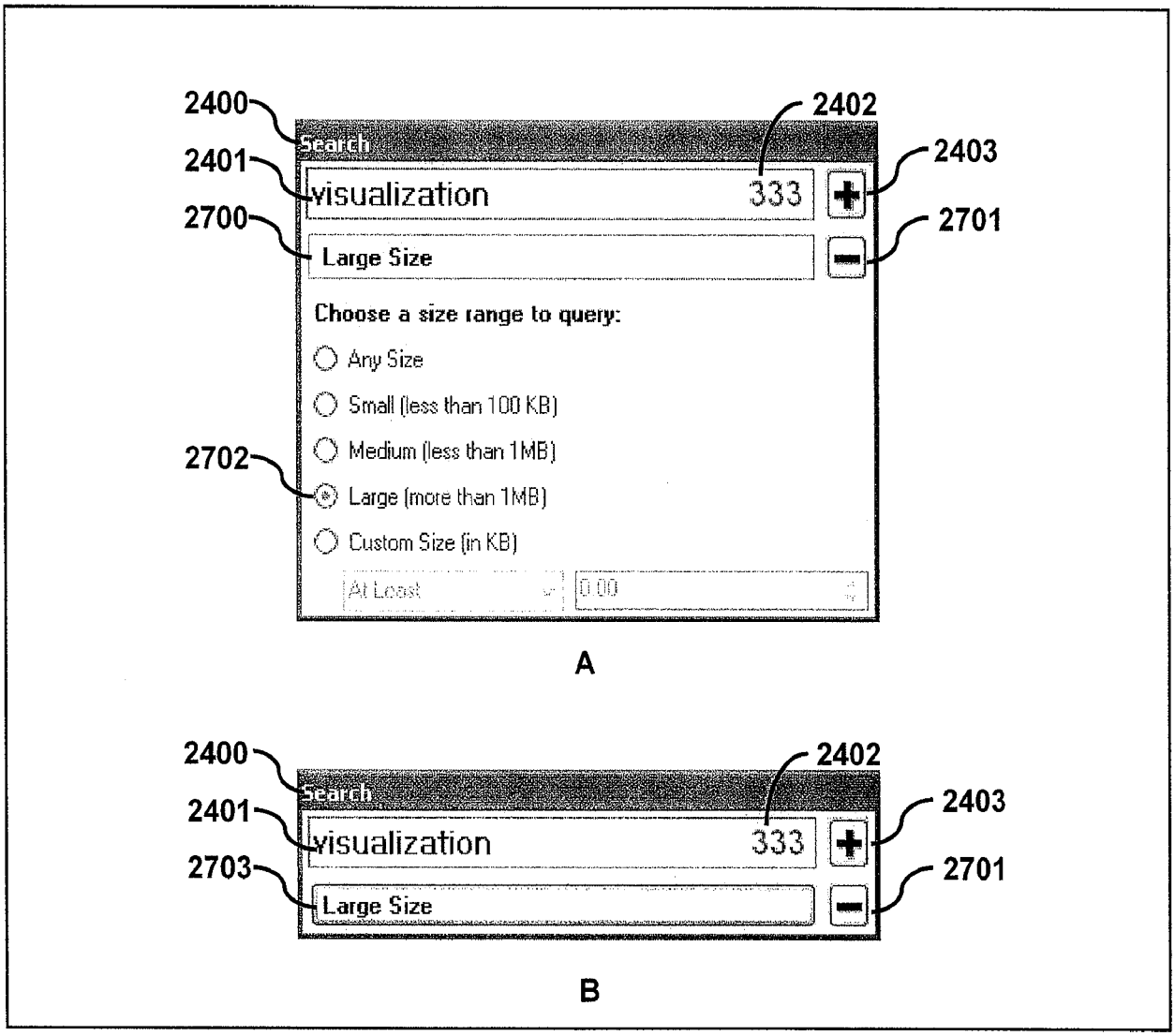
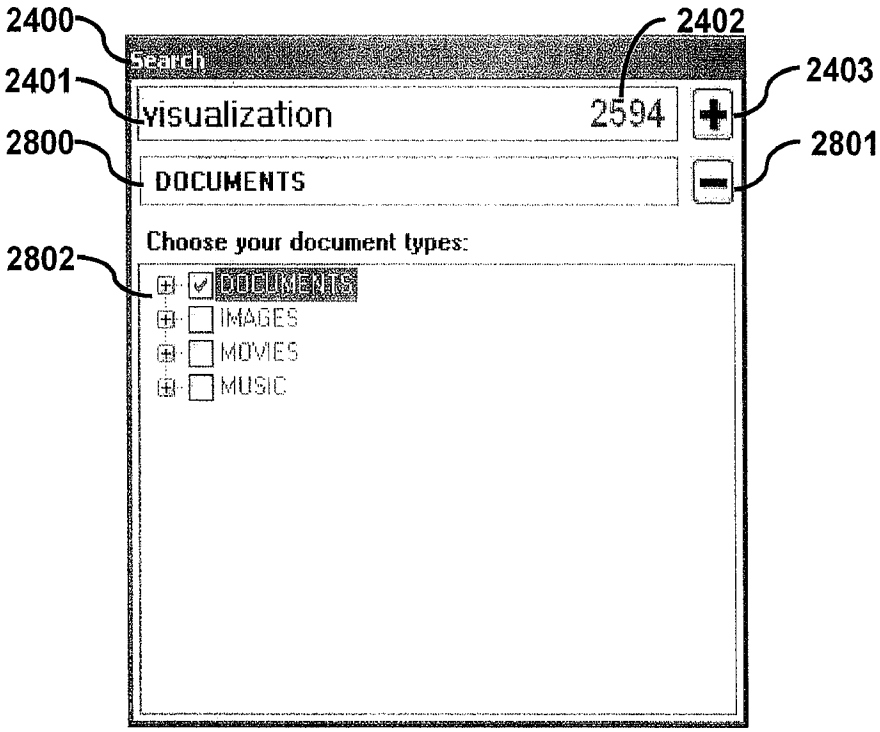
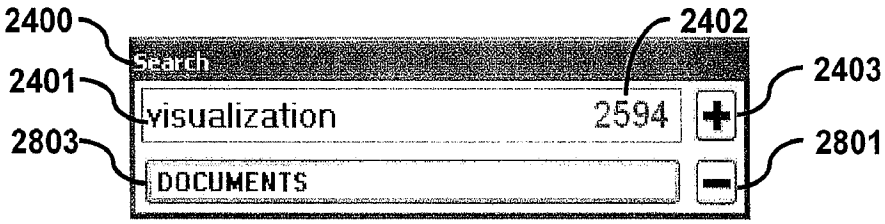

2400
2401
2700
2402
2403
2701
Search
visualization
333
Large Size
Choose a size range to query:
Any Size
Small (less than 100 KB)
Medium (less than 1MB)
2702
Large (more than 1MB)
Custom Size (in KB)
At Least
0.00
A
2400
2401
2703
2402
2403
2701
Search
visualization
333
Large Size
B

Fig. 27

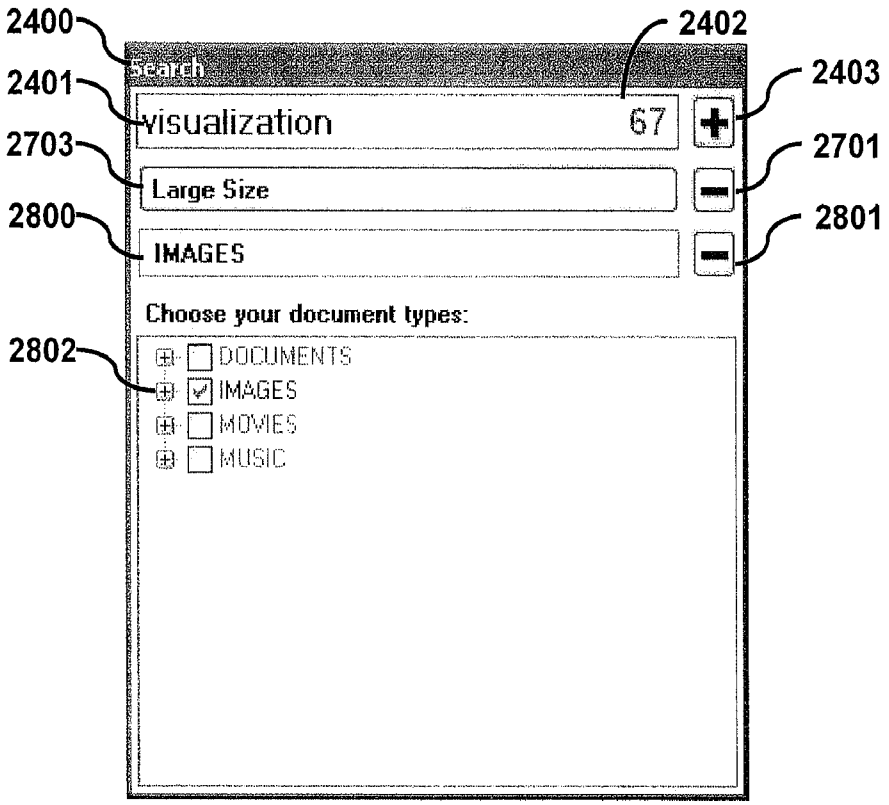

2400
2402
Search
2401
visualization
2594
2403
2800
DOCUMENTS
2801
Choose your document types:
2802
DOCUMENTS
IMAGES
MOVIES
MUSIC

A

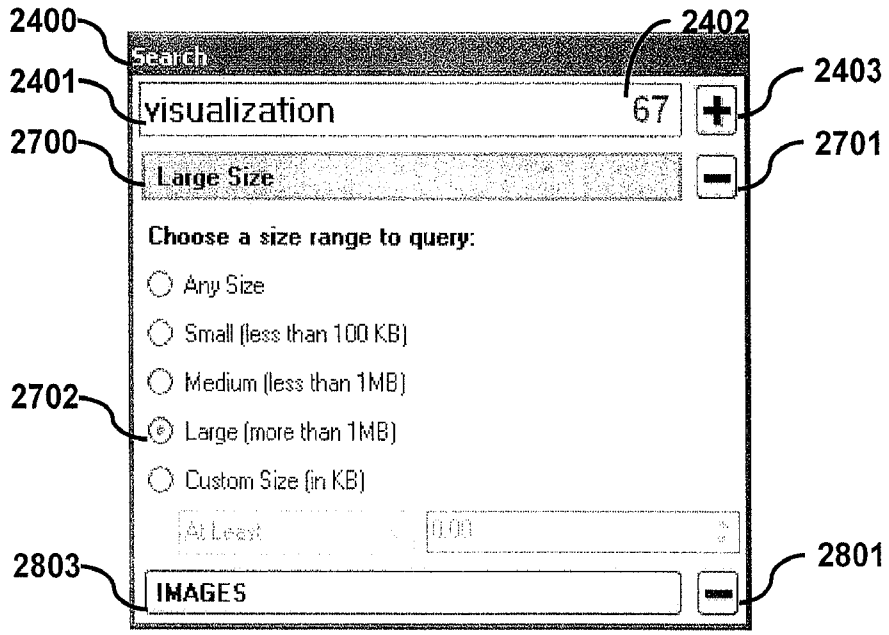

2400
2402
Search
2401
visualization
2594
2403
2803
DOCUMENTS
2801

B

Fig. 28


2400
2401
2703
2800
2802
2402
2403
2701
2801
Search
visualization
67
Large Size
IMAGES
Choose your document types:
DOCUMENTS
IMAGES
MOVIES
MUSIC

A


2400
2401
2700
2702
2803
2402
2403
2701
2801
Search
visualization
67
Large Size
Choose a size range to query:
Any Size
Small (less than 100 KB)
Medium (less than 1MB)
Large (more than 1MB)
Custom Size (in KB)
At Least
IMAGES

B

Fig. 29

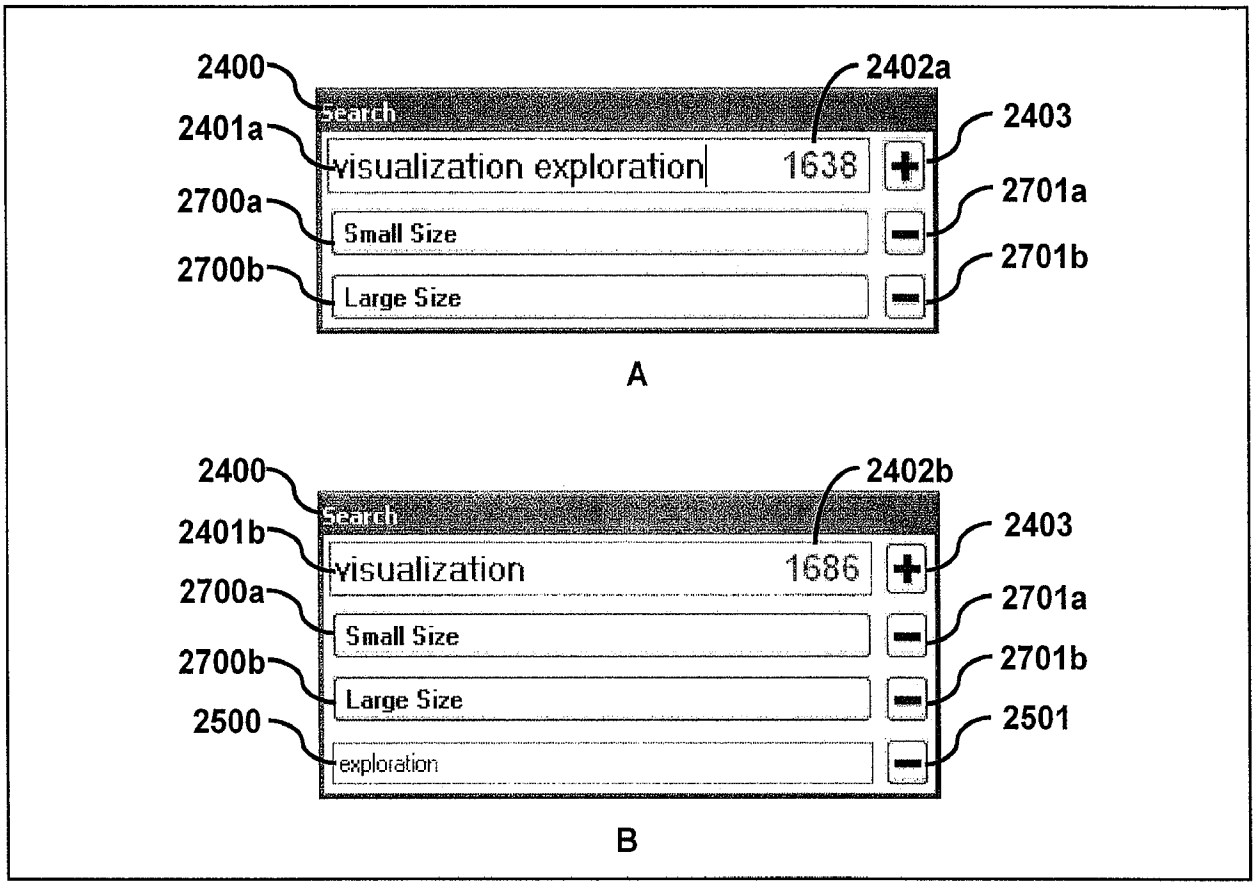

2400
2402a
Search
2401a
visualization exploration
1638
2403
2700a
Small Size
2701a
2700b
Large Size
2701b
A
2400
2402b
Search
2401b
visualization
1686
2403
2700a
Small Size
2701a
2700b
Large Size
2701b
2500
exploration
2501
B

Fig. 30