Alleyoop: Interactive Information Retrieval System with Sketch Manipulations

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***Abstract*—The Alleyoop system enables users to retrieve information through sketch manipulations. A number of information retrieval systems already enable users to casually search and browse through the Web. These systems are useful for conventional input forms where a user uses a keyboard to input a keyword to a dialog box. However, they are not suitable for pen-based input styles. Users of pen-based computers have to input a query to a fixed dialog box by drawing the query. In contrast, the Alleyoop system is designed for pen-based computing, so users can interactively retrieve information through sketch manipulations. When a user draws a closed curve and a keyword, information nodes related to the keyword are collected automatically inside the closed curve. The user can also create a Venn diagram by continuously drawing closed curves and keywords, and form more complex queries for information retrieval. Moreover, the system allows the user to create a layout by drawing strokes freely, so he/she can set the information nodes on the layout and see them in detail. In this paper, we describe our Alleyoop system and how it can be effectively applied.**

Keywords-Information Retrieval; Information Visualization; Sketch and Paint Manipulations; Interactive System.

I. INTRODUCTION

As computer hardware and software are continuously improved, it becomes possible to more quickly express a wider variety of information (e.g., images, movies, documents, and Web pages). Also, many types of computers (e.g., augmented reality (AR) systems, ubiquitous computers, and personal digital assistants (PDAs)) have been developed to allow users to naturally interact with the information space. In the future, these diversifications will be advanced rapidly, so natural and simple visualization techniques for information retrieval are needed.

Numerous systems have been designed for information retrieval. Web based search engines (e.g., Google and Yahoo) have become popular for casual use. Combining rough and detail search methods is one important element, since they have to treat huge amounts of information. These systems are based on conventional input methods, so a keyboard is used to input a keyword to a fixed dialog box. On the other hand, pen-based computers such as PDAs and tablet PCs have become popular recently. They are characterized by simple sketch manipulations similar to drawing a picture on paper in the real world. This sketch-based interaction has been developed especially for creative activities [4, 5, 6]. Sketch interaction is not especially useful for communicating details, but is effective for approximate and casual use. In these systems, a user can use the entire system window as a workspace. Also, sketch based information retrieval systems have been developed. When a user draws a picture, the system finds similar images from the database automatically. However, they do not provide combination between rough and detail search methods. Some systems focus on the relationship between sketch and layout. Although, Maya paint effects allows users to set psudo-3D objects in the scene using 2D brush strokes, their target is not information retrieval. Thus, as the original applications have not supported information retrieval, users have to use conventional retrieval applications with pen-based input styles.

Therefore, we have been developing a unique information retrieval system based on simple sketch manipulations for pen-based computers [1, 2]. A feature of our design is that all the manipulations required for information retrieval are based on sketch manipulations and that a user can use the entire window space as a search area. Thus, the user can freely use the whole application window as both an input and a search area. In order to retrieve information, the Alleyoop system mainly provides two interactions: rough and detail searches. The rough search is to collect related information nodes. A user of the Alleyoop system first draws a closed curve and then draws a keyword inside the curve. The system automatically recognizes both the curve area and the keyword after the user has drawn them. Information nodes related to the keyword are then collected within the curve area. In addition, by making a continuous series of simple drawings, the user can create a Venn diagram to form a more complex query. The detail search is to see the information nodes in detail. After collecting the nodes, the user creates an original layout by drawing strokes. The information nodes are set onto the layout, so the user can see the nodes in detail. As both search interactions are based on sketch manipulations, the user can interact with an information space freely and easily.

In this paper, we describe a prototype of the Alleyoop system and how it enables users to handle information through interactive drawing. The next section describes the related work of the Alleyoop system. Section 3 describes the system design. The system overview is mentioned in detail in Section 4. In Section 5, we describe the implementation of the system. In Section 6, we discuss the system based on comments made by visitors. Section 7 concludes the paper.

II. RELATED WORK

Our system focuses on pen-based information retrieval and allows users to retrieve information through creative activities. Here, we describe work related to our concepts such as information visualization and sketch interfaces.

While considerable research has been done to support the use of information visualization [3] for retrieving information, existing visualization systems are not designed to treat all data sets in a common way. Actually, by applying visualization techniques such as zooming and scaling, specialized systems can be designed to enable efficient visualization of huge amounts of data [8, 9, 11, 12], but such systems are not effective for simple visualization of moderate amounts of data. In particular, in the case of 3D layouts, the navigation methods become as important as the layouts as the amount of data increases. Although some systems include different layouts, these layouts are still designed on the basis of the system designers' intention [13, 14]. Thus, a casual visualization technique is needed for a wide variety of situations.

Several pen-based computers have been developed. At the consumer product level, PDAs and tablet PCs have become common. These computers allow users to interact with the computer environment by means of simple sketch manipulations [4, 5, 6] and are effective for casual and rough inputs such as sketching in the real world. These sketch-based systems allow users to perform 2D drawing manipulation of 3D computer graphics (CG) creations, so the difficulties of 3D CG are avoided. Characteristically, the manipulations required for these systems are simple and similar to drawing a stroke on a piece of paper with a pen. Sketch [4] users can draw 3D curves by performing 2D manipulations. This system calculates a 3D curve by combining a 2D stroke and a shadow stroke. Users of Harold [5] and Tolba [6] can create flat models in a 3D space using sketch-based manipulation, effectively creating a 2.5D scene in a 3D space.

III. ALLEYOOP DESIGN

One design focus is to enable interactive drawing for information retrieval. Such a system would let users operate the system more freely and easily when engaging in creative activities. Another design focus is to provide both rough and detail searches. This combination makes it possible to treat huge amounts of information. We consider the following features as important to achieving our design goal.

A. *Simple Creative Interaction*

Simple creative interaction was important to realize our concepts because this type of interaction provides flexibility. Integrating drawing with information retrieval enables a user to use the whole workspace interactively, much like drawing a picture on a piece of paper. In such an environment, the user can draw layouts to display information nodes and keywords related to the nodes anywhere within the workspace. While the system treats many types of information (e.g., images, movies, 3D models, documents, and Web pages) as visualized information nodes, we used mainly image data as the information node. An information node means a piece of information on the screen. Also, depending on how a line is drawn, the user can create either simple or complex queries for information retrieval. All the elements related to information retrieval such as layout design and keyword drawing should be realized flexibly.

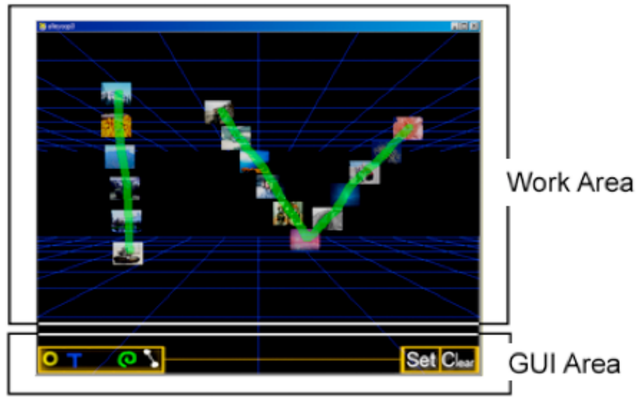


Figure 1. System Overview: The system is divided into two areas, work and GUI areas. Some GUI buttons are included in the GUI area to control pen attributes.

B. *Rough and Detail Searches*

Combining rough and detail search methods is one important element, since we have to treat huge amounts of information. This combination has been supported by conventional Web search engines such as Google and Yahoo. Web users performing searches first collect related information roughly by setting queries and then see each information node in detail one by one. The Alleyoop system also treats huge amounts of information, so it should provide these rough and detail processes. Our system arranges these processes by sketch manipulations (setting an area and creating a layout). In such an environment, the user first creates an outline to collect information nodes roughly and then creates an original layout to see each information node in detail.

C. *Node Animation*

Node animation plays an important role in our information retrieval. For example, through the animation, users can know the relationship between node and keyword dynamically and retrieve extra information. Our system integrates node animation with the user's drawing.

IV. SYSTEM OVERVIEW

Figure 1 shows the user interface for our system. The system is divided into two areas: work and graphic user interface (GUI) areas. The GUI buttons at the bottom of the figure allow the user to choose pen attributes and draw four types of strokes (area, text, layout, and relation strokes). The first button is for the *area pen*, which is used to draw a closed curve. The second button is for the *text pen*, which is used to draw a keyword. The third button activates the *layout pen.* The user can create a 2D layout by drawing a layout stroke. The fourth button is for the *relation pen*, which allows the user to add relationships between different pieces of a visualized information node.

The interaction is divided into two phases: rough and detail searches. The area and text strokes are used for the former and the layout and relation strokes are used for the latter. The color of the stroke depends on the color of the button, so the user can use stroke colors like paint colors.

The buttons to set and clear GUIs are located in the area. The "Set GUI" button is used to set visualized information alongside the user's strokes and the "Clear GUI" button is used to clear the work area.

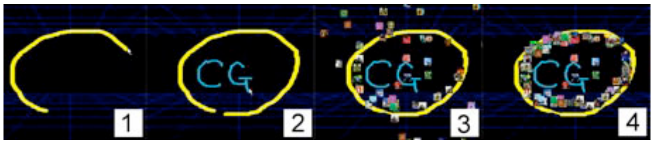


Figure 2. Rough search: A user first draws a closed curve with the area pen and a keyword inside the curve with the text pen. As the system recognizes the area and keyword, related information nodes appear inside the area.

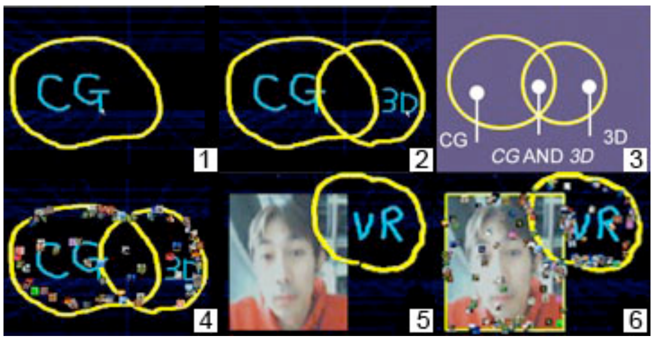


Figure 3. Drawing a Venn diagram: By continuously drawing crossed curves and keywords, a user creates a Venn diagram and can then retrieve information by forming a complex query (1, 2, 3, 4). It is possible to create a Venn diagram between a drawing and an image that contains character information (5, 6).

A. Rough Search

A user can collect information nodes roughly by using the area and text pens. In spite of the simple interactions, it is possible to form complex queries through a series of continuous drawings. The system can also be used in combination with other types of datasets, such as an image dataset.

1) Drawing a closed curve and a keyword

A user starts interacting with the information space by drawing a closed curve with the area pen (displayed as a yellow stroke) and a keyword with the text pen (displayed as a blue stroke). The closed curve provides an area where information nodes related to the keyword will be collected and the keyword provides a query to search for related information nodes from a database. Figure 2 shows an example of simple information retrieval through drawing. First, the user draws a closed curve, and then draws a keyword *CG* inside the curve (1, 2). The system recognizes the area and keyword, so information nodes related to the keyword move to the closed curve (3, 4). The related information nodes are moved with a force depending on the distance between the node position and the center of the curve. As a result, the information nodes related to the keyword are collected inside the area.

2) Venn Diagrams

By continuing to use simple drawings, a user can form more complex queries. Figure 3 shows an example of creating a Venn diagram by continuing to draw closed curves and keywords. For example, when a user retrieves information that has two keywords *CG* and *3D*, the user first draws a closed curve and *CG* (1), and then draws another closed curve and *3D* (2). Information nodes related to both keywords appear in the shared area of the Venn diagram (3, 4). From the information distribution results on the Venn diagram, the user can retrieve information roughly and recognize relationships between nodes. Moreover, the user can use an image to create a Venn diagram by combining drawings with image data. In this case, a file name or contained character information becomes a query for the Venn diagram. The figure shows an example of creating a Venn diagram between an image and a drawing (5, 6). In this example, related nodes with both VR and the file name appear.

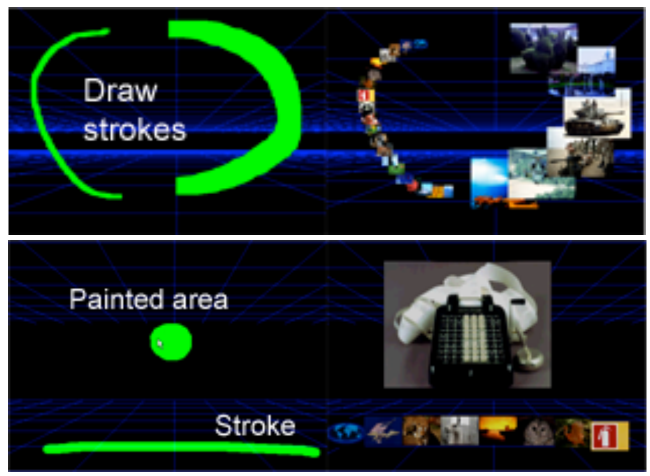


Figure 4. Detail search: The user can create a layout by drawing a layout stroke to see information nodes in detail. It is possible to control the information output by selecting the appropriate pen width (top) and adjusting the painting area (bottom).

B. Detail Search

After collecting related information nodes roughly, a user can see them in detail by using an original layout the user created. The user can create a layout with the layout stroke and add relationships between nodes with the relation stroke.

1) Layout Design

Figure 4 shows how the user can create a 2D layout by selecting the layout pen and drawing a stroke with it (displayed as a green stroke). Since a set of images is automatically displayed alongside the user's strokes, he/she can create a layout that freely displays the images in the work area. Thus, the user can place information nodes onto drawn words and pictures. In addition, as the pen width is directly related to the image size, larger images appear alongside the stroke if the user draws a bold stroke, while smaller images appear if he/she draws a thin stroke in the work area (Fig. 4 (top)). A painted area is recognized as one big point, so the system positions a large image alongside the painted area (bottom). Thus, the user can select a large image when painting to see it in more detail (Fig. 4 (bottom)).

Figure 5. Relation stroke: The user can create a layered layout by drawing relation strokes (top). Multiple information can be connected to single information nodes at the same time (bottom).

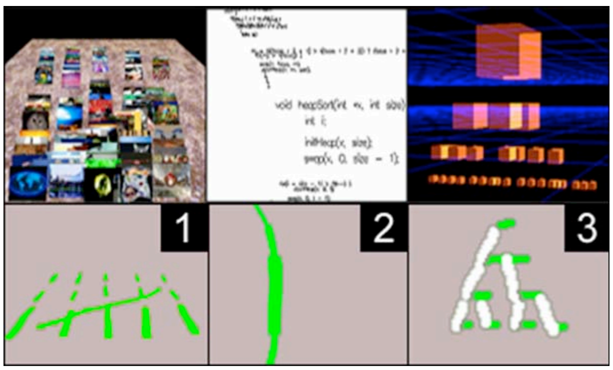


Figure 6. Layout creation with our system. Each layout was created by drawing simple strokes.

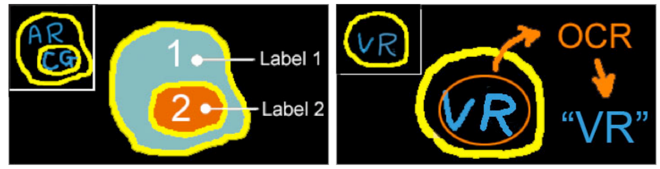
Conventional information visualization systems enable users to visually search and browse through a layout to locate grouped information. While these layouts are pre-defined and useful in applications considered by designers, users cannot freely change or redesign them. In contrast, our system integrates information visualization with sketch manipulations and allows users to create a layout freely and easily.

2) Relationships between Nodes

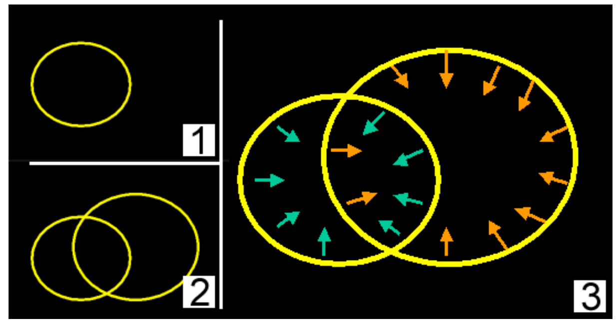
Figure 5 shows how the user can add relationships to connect focused images by drawing a relation stroke (displayed as a white stroke) from one image to another. As the pen width directly corresponds to the relationship value, the user can establish and control relationships between images. The clicked image in the figure becomes the parent for the connected image, and the system establishes the relation through the pen width. This manipulation is especially useful in grouping new information, such as digital photographs and user creations such as painted images or 3D models. Users can now easily take pictures using digital cameras and, as a result, have a huge amount of original image data in their computers. This stroke is useful for such an environment. Moreover, users can create simple information visualization layouts through continuous, straightforward manipulations with our relation techniques (Fig. 6).

V. IMPLEMENTATION

Next, we consider the implementation of the Alleyoop system. Users' drawing manipulations are reflected in the bitmap data that make up the workspace. The workspace has four bitmap layers and each layer is used for each pen attribute. The system is basically realized through simple sets of image processing.



(a) The system labels the user's drawing area (left) and then recognizes keywords by using an OCR library (right).



(b) Labeling of a Venn diagram. The system uses mouse trace data to determine the shared area and its keyword.

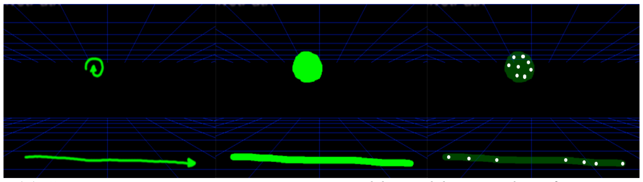
Figure 7. Implementation of rough searching. The implementation is divided into two parts: labeling of the user's drawing area and recognition of a keyword.

A. Rough Search

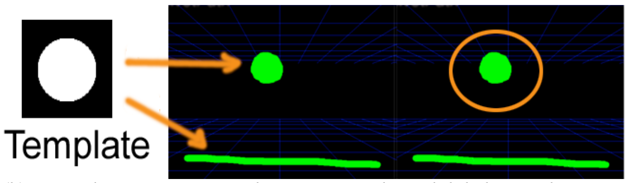
When the user draws an area with the area pen and a keyword with the text pen, the system stores four types of data (stroke-ID, mouse-trace, area-bitmap, and keyword-bitmap data).

When the user pushes the "Set GUI" button after drawing a closed curve and a keyword, the system starts the calculations for the user's drawing. For the closed curve area, the system labels the inside of the area (Fig. 7 (a-left)). This labeling process depends on the mouse trace data, which the system uses to determine the inside or outside area. For the keyword bitmap data, the system sends the data to an optical character recognition (OCR) library and recognizes the keyword meaning (Fig. 7 (a-right)). When the user creates a Venn diagram through continuous drawing of a closed curve and a keyword, the system uses the mouse trace data to determine the shared area and its keyword (Fig. 7 (b)). In the event the combination includes an image, the system labels the inside of the image area with the same label as the drawn curve. The image is thus treated as the drawn curve. After the calculations, the system contains three types of data (area ID, area position, and keyword) for each labeled area.

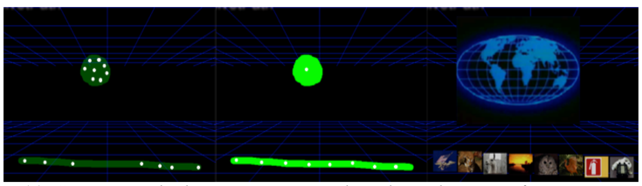
Next, calculations for the node animations start. Each node is subject to a force that depends on the node's relationship with the keyword. This calculation is done by a spring model [9]. The node then moves until it is in the appropriate area for the relationship. The system has an original database containing three types of data: node names, keywords, and relation levels. The database is loaded when the system starts.



(a) System contains mouse-trace, pen-width, and bitmap data for user drawings.



(b) Painted area is recognized as one point through labeling and pattern matching of screen image.



(c). System recalculates mouse trace data depending on information size and then sets information.

Figure 8. Detail search implementation and drawing area calculation.

B. *Detail Search*

As Fig. 8 shows, for a detail search the system stores three types of data (i.e., mouse-trace, pen-width, and bitmap data from the screen) for a set of layout strokes (a). The bitmap data is labeled and then matched to simple template data (b). The system recognizes what shape was drawn (e.g., line or circle) through template matching with the labeling data. If the results for labeling are different from the template pattern, the system recognizes strokes as lines and sets visualized information. Next, the trace data is recalculated to maintain the same distance according to pen width, enabling a painted circle to be recognized as one big point (c). The amount of visualized information shown on the screen depends on the stroke length. Less information is visualized if the total length of the line on which visualized information is laid out is longer than the stroke. As a result, visualized information is automatically set along with the user's strokes. These calculations to set information are done when the user draws strokes and pushes the "Set GUI" button.

In connecting with a relation stroke, the system recognizes visualized information under the starting point as a parent and visualized information connected with the relation stroke as a child of the scene graph. The system defines the size and position parameters of the child by taking the stroke width into account. The child image that is included in the layout becomes half the size of the parent, because they are connected with a double-sized pen. These results are saved by the system database.

VI. DISCUSSION

Here, we discuss user interactions with Alleyoop based on comments made by visitors to our demonstrations.

A. *Rough Search*

In our demonstrations, visitors quickly understood the system concepts and interaction methods. It was not difficult for them to recognize the relationships between information nodes and keywords directly through Venn diagrams, or to use the whole workspace for free drawing. Most visitors were able to create simple Venn diagrams and set related nodes onto them after a simple demonstration. While conventional information retrieval systems require users to input a keyword to a dialog box field, our system allows them to use the entire workspace and retrieve information through creative activities. Since the system facilitates creative activities, we expect its users will be able to create more original and effective drawings for information retrieval. We also received good reactions from visitors regarding the combination of drawings and images to create a Venn diagram. Our system can use various types of information included in images, such as characters and words. Through sketch manipulations, a user can retrieve information without drawing a keyword. Moreover, the user can use other types of data, such as real-world information, to create Venn diagrams. If the information contains text and characters, these information elements are used as queries for information retrieval. Figure 9 shows an example of using real-world information as a Venn diagram element. The user first captures real-world information through a digital camera attached to his/her computer (1, 2) and then draws a closed curve around a keyword on the captured data and another closed curve to collect information nodes (3, 4). As the system recognizes the keyword inside the first closed curve, related information nodes appear inside the second curve.

B. *Detail Search*

Most visitors designed original layouts through simple manipulations. Although none of them created a complex layout, they were able to easily create simple layouts and created words and pictures to visualize grouped information. This indicated that they quickly understood our system concepts and interaction methods. Our system was designed to enable users to design simple layouts and freely redesign layouts. The visitors were able to casually create simple or unusual layouts not requiring special design skills and encountered no difficulties in this casual use. Allowing users to design and create layouts freely in and of itself, however, does not ensure an easy design process. Accordingly, our system provides sketch and paint techniques instead of complex parameter settings. This enables even a simple stroke to become a kind of layout and thus allows design difficulties to be avoided. We also showed through simple demonstrations that both sketch and paint interactions could be used to directly control parameters (e.g., scale and relation). The visitors reacted particularly favorably to the relation stroke because it made it possible to handle the user's original data set while controlling the relation rate by adjusting the pen width. They generally held their original data set in a folder named "Related Data", and all were able to establish relationships between data and create simple databases using only the relation strokes.

Figure 9. Combination with real-world information: Capturing real-world information as a picture (1, 2) and drawing two closed curves (3, 4). One curve (shown in yellow) means an area and the other (shown in blue) means a keyword.

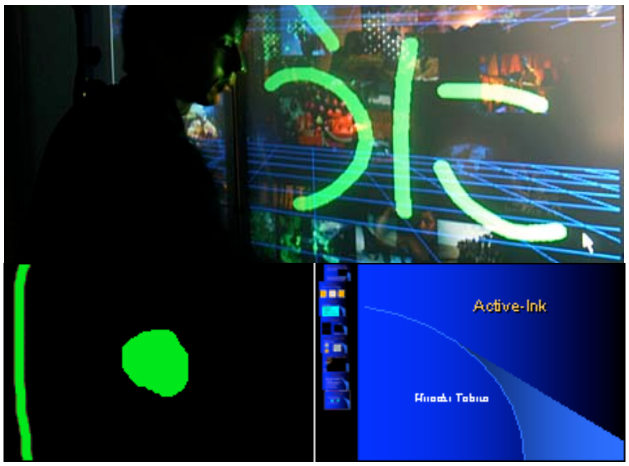


Figure 10. Combination with wall-type display. A user sets data by drawing a stroke on a wall-type display.

Some visitors had questions related to the system's lack of effectiveness with detailed manipulations. A few of them also said they would have preferred more complex layouts and relationships. However, our goal was to enable simple and convenient interactions that would allow casual users to freely utilize the system. As complex manipulations and GUIs would have increased the complexity of the layout and relations, we did not include these in our system.

C. Communication

It is also possible to combine our system with AR systems based on tablet computers [7] and with ubiquitous computing environments. As the user generally interacts with the computer to display and change visualized information in these environments, information layout techniques are as important as interaction techniques. To enable more natural interactions, the visualized information size and position need to change depending on the situation and type of computer to allow more natural interaction with the information space through both visualization techniques and AR systems. Also, as the interactions should be simpler than for normal computing in these systems, a combination of our system and AR systems promises to be quite useful. For example, in case of using wall-type AR systems, the user can use the wide information space freely (Fig. 10 (top)). Our system also provides good support for displaying information for presentation in meetings (Fig. 10 (bottom)). Here, the user can draw the most effective layout according to the situation and type of information.

D. Future Work

Our system is so far only at the prototype stage, so we are planning to further improve it by combining with other types of database. Then, we will conduct practical user tests.

As a subject for future work we plan to combine our system with AR system to enable it to support more natural interactions [10]. Combining it with a gesture recognition system would be a particularly effective way to achieve this.

VII. CONCLUSIONS

The Alleyoop system enables users to retrieve information through sketch manipulations. The system is divided into two phases: rough and detail searches. We have described our design concepts and a prototype of the Alleyoop system. Although the interactions based on sketch manipulations are very simple, users can use them to set complex queries and create original layouts freely.

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