Catenaccio: Interactive Information Retrieval System through Drawing

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ABSTRACT
The Catenaccio system integrates information retrieval with sketch manipulations. The system is designed especially for pen-based computing and allows users to retrieve information by simple pen manipulations such as drawing a picture. When a user draws a circle and writes a keyword, information nodes related to the keyword are collected automatically inside the circle. In addition, the user can create a Venn diagram by repeatedly drawing circles and keywords to form more complex queries. Thus, the user can retrieve information both interactively and visually without complex manipulations. Moreover, the sketch interaction is so simple that it is possible to combine it with other types of data such as images and real-world information for information retrieval. In this paper, we describe our Catenaccio system and how it can be effectively applied.

CR Categories: I.3.6 [Computer Graphics]: Methodology and Techniques – Interaction Techniques; I.3.4 [Computer Graphics]: Graphics Utilities – Software support

Keywords
Information retrieval, sketch manipulations, Venn diagram, interactive system.

1. INTRODUCTION
Pen-based computers, such as personal digital assistants (PDA) and tablet PCs, have been developed. These computers are characterized by simple sketch interfaces similar to drawing a picture on paper in the real world. This drawing manipulation is not especially useful for communicating details, but is effective for general use. It is especially useful for creative activities, so there have been a number of research reports on improving sketch manipulation [1, 2, 3].

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In addition, some game devices (e.g., Nintendo DS [4]) support such kinds of interactions and provide many types of game content. In these systems, a user can use the entire system window as a workspace and create 3D CG from 2D drawings. However, as the original applications may not support information retrieval, the user has to use conventional retrieval applications along with pen-based input styles.

Considerable research has been done to support the use of information visualization for retrieving information [5]. Technical visualization methods such as zooming and scaling can be used to effectively display huge amounts of data [6, 7, 8]. However, existing visualization systems focus on mouse manipulation (e.g., click and drag), so they are not effectively designed for pen-based interactions such as a drawing.

The most popular method of retrieving information is no doubt keyword searching. Search engines via the Web (e.g., Google and Yahoo) have been generally used for keyword searching [12, 13], and people feel that they cannot live without such search engines. Generally, keyword searching requires users to input one or more keywords. In these systems, users can retrieve information related to the keywords with Boolean operations (e.g., AND, OR and NOT). However, the systems are based on conventional input methods. Users of pen-based computers have to write a query into a fixed dialog box with a stylus or pen.

Therefore, we have been developing an information retrieval system based on simple sketch manipulations. Our goal is to devise an effective and simple information retrieval system that works on pen-based computers, so we integrated a keyword searching that is one of the most usual methods with sketch manipulation that is one of the simple interactions. In our system, users retrieve information by drawing a Venn diagram instead of inputting keywords to a dialog box. Because the Venn diagram can be used to display Boolean operations (e.g., AND, OR, and NOT) visually and create some relationships at the same time, users can recognize the relationships at a glance. Moreover, the system allows users to use other types of data as elements in a Venn diagram (Fig. 1).

In this paper, we describe our *Catenaccio* system that integrates information retrieval with sketch manipulations, and explain how it can be effectively applied for information retrieval.

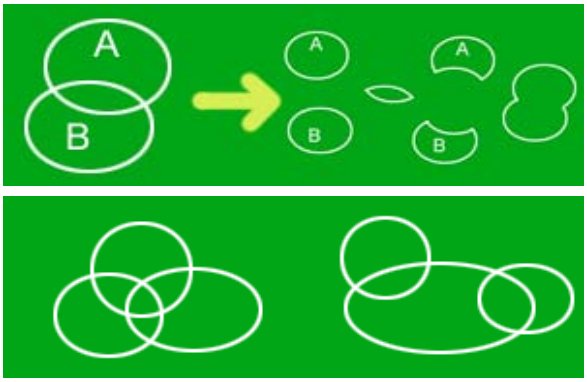

Figure 1: Venn diagram: Venn diagram can be used to display Boolean operations and some relationships at the same time (top). The user can create an original Venn diagram (bottom).

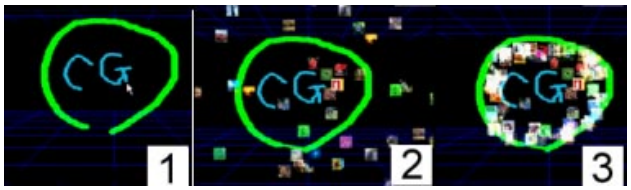

Figure 2. Basic manipulation: A user of the Catenaccio system draws a circle and writes a keyword inside that circle. Information nodes related to the keyword are then collected within the circled area.

2. RELATED WORK

A wide variety of information visualization systems are used for information retrieval [5]. Treating information as visualized nodes (e.g., images and simple shapes) allows users to interact with the information space visually. Moreover, several techniques (e.g., scaling, zooming, focus and context) are used to display a huge amount of information more effectively [6, 7, 8, 19]. Especially, spring model [11] provides useful ways to recognize the relationships between nodes. In these systems, related nodes move when the user clicks and drags a node. That is, node positions are dynamically changed through the user manipulations, so users retrieve information interactively. InfoCrystal [9] is also a visual tool focused on information retrieval. The system uses Venn diagrams to treat huge amounts of information effectively. However, conventional systems are designed for mouse interactions (e.g., click and drag) and their layouts are predefined, so they are not suitable for Pen-based computing, especially drawing or writing by hand.

There are also several sketch interfaces focusing on pen-based computing [1, 2, 3]. Most of them enhance drawing manipulations and focus on 3D creations performed with 2D manipulation. Characteristically, the manipulations required for these systems are simple and are similar to drawing a stroke on a piece of paper with a pen. Sketch [1] 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 [2] and Tolba [3] can create flat models in a 3D space by using sketch-based manipulation, effectively creating a 2.5D scene in a 3D space.

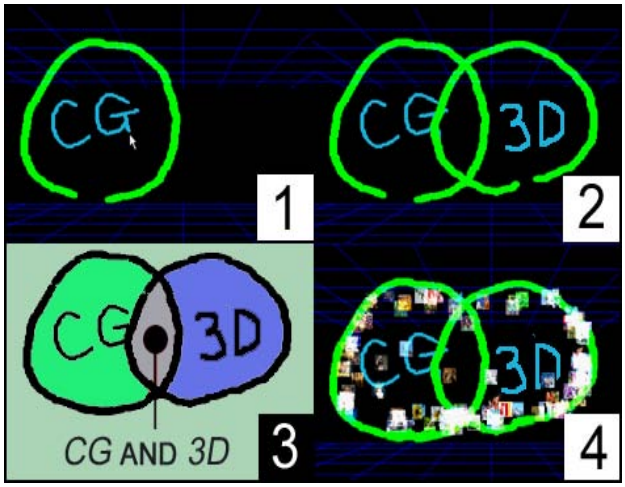

Figure 3. Drawing a Venn diagram: By repeatedly drawing circles and keywords, users create Venn diagrams, and can then retrieve information by forming complex queries. Information nodes related with both "*CG*" and "*3D*" are collected.

3. SYSTEM OVERVIEW

The Catenaccio system is focused on pen-based computing and provides an interactive and visual information retrieval environment of using drawing manipulations.

3.1 Drawing Circles and Writing Keywords

A user of the Catenaccio system draws a circle and writes a keyword inside that circle. The system automatically recognizes both the circle area and the keyword. Information nodes related to the keyword are then collected within the circled area. By making a continuous series of simple drawings, the user can create a Venn diagram to form a more complex query. Since the entire window is both a search area and a drawing canvas, the user can use the workspace freely.

Since all the manipulations required for information retrieval are based on sketch manipulations, users can design an original Venn diagram related their interests. Thus, users can freely exploit the whole application window as both an input and a search area and retrieve information without complex GUIs.

The circle 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. By continuing to use simple drawings, users can form more complex queries. The related information nodes are moved with a force that depends on the distance between the node position and the center of the circle (Fig. 2).

Figure 3 shows an example of creating a Venn diagram by continuing to draw circles and keywords. In the example, when a user retrieves information that has two keywords "*CG*" and "*3D*", the user first draws a circle and writes "*CG*" (Fig. 3 (1)), and then draws another circle and writes "*3D*" (Fig. 3 (2)). Information nodes related to both keywords appear in the shared area of the Venn diagram (Fig. 3 (3 and 4)). Moreover, in the Venn diagram, the user can view four areas at a glance (Fig. 3 (3)).

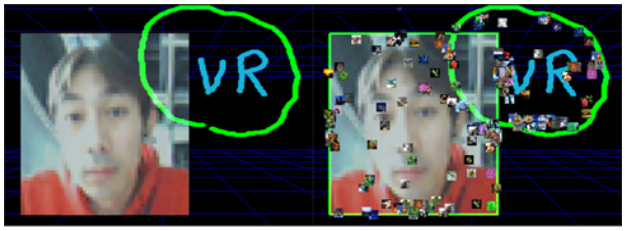

Figure 4: Venn diagram of a drawing and an image, and Venn diagram of a drawing and an image that contains character information.

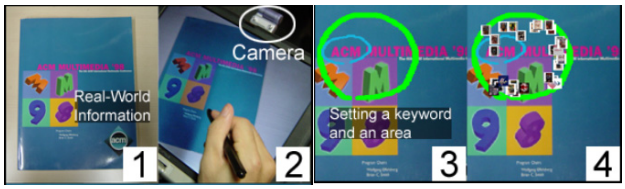

Figure 5: Combination with real-world information: Capturing real-world information as a picture (1, 2) and drawing a circle around the keyword brings up related information nodes (3, 4).

3.2 Combination with Other Types of Data

Users can now easily take pictures using digital cameras and cell phones that contain CCD cameras. As a result, they may have a huge amount of original image data in their computers. These data include some information such as name, time, or place, so we considered using them for information retrieval.

We have developed prototype applications to explore the potential of Catenaccio. A Venn diagram is basically constructed by combining keywords and areas, so it is possible to combine that diagram with other types of data such as images and real-world information. Images contain name, time, or place information, and that information becomes a good trigger for retrieving other information and it can be used for queries. In addition, the image data has a rectangular shape that is useful for setting an area by controlling its position and size.

The example in Figure 4 shows how users can use images to create Venn diagrams by combining drawings with image data. In the example, a file named *"Mr. Tobita"* becomes a query for the Venn diagram, so information related to *"VR"* AND *"Mr. Tobita"* is collected. In this case, even if users have forgotten someone's name, they can still retrieve related information through image contents.

Figure 5 shows an example a Venn diagram with real-world information. Generally, using captured data for an interaction trigger is a common technique in AR systems [20]. We also use it for elements of Venn diagrams. Users first capture real-world information through digital cameras attached to their computers (Fig. 5 (1, 2)), and then draw circles around keywords on the captured data and another circle to collect information nodes (Fig. 5 (3)). As the system recognizes the keyword inside the first circle, related information nodes appear inside the second curve (Fig. 5 (4)).

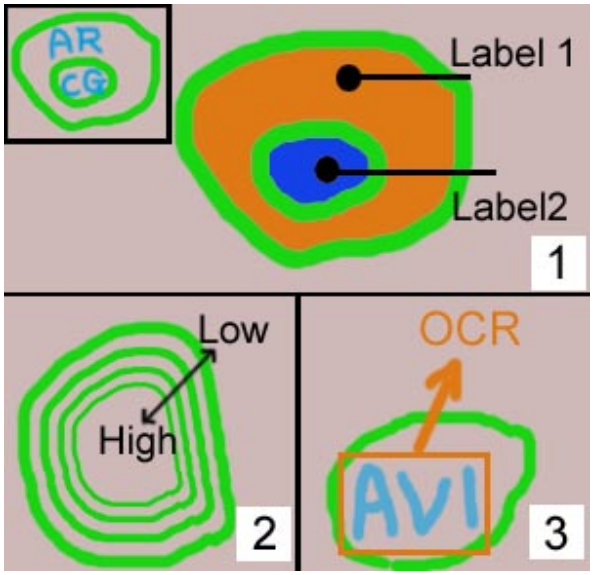

Figure 6: Recognition of user drawings: The system labels the user drawing area (1, 2). The system recognizes written keywords by using an OCR library (3)

Previously, we have proposed a similar information retrieval system [10]. That system provides natural interactions, however, it completely depends on real-world objects. However, Catenaccio provides not only real-world information, but also drawing manipulations. Thus, the user can retrieve information even if there are not enough real-world objects.

4. IMPLEMENTATION

The entire workspace is bitmapped as in conventional 2D paint systems, and user drawing manipulations are reflected in the bitmap. The system supports two types of drawing, writing keywords and area drawings. The keyword writing is displayed as green, and the area drawing is displayed as blue. To set an area, the system labels the inside of a green area and knows the size and position of the area (Fig. 6 (1)). Then, the system divides the area into four layers for node animations (Fig. 6(2)). For keyword writing, the system sends the result to an OCR library to search for its meaning (Fig. 6 (3)).

Catenaccio is a prototype system now, and the relationship between keywords and information nodes are predefined in a temporary database. The database contains three types of data: node names, keywords, and relationship levels. After the image recognition processes, nodes related to the keyword are selected and start moving until they are in the area appropriate to their relationship. The force is calculated by spring model [11]. For example, the node with the strongest relationship with the keyword receives a force that takes it to the deepest area.

5. DISSCUSSION

We have had some opportunities to demonstrate our system. Here, we discuss user interactions with Catenaccio based on comments made by visitors to our demonstrations. Also we consider the limitations of the system and our plans for future work.

From our demonstrations, the visitors quickly understood the concepts of our system that integrates information retrieval with

drawing manipulations. Using Venn diagrams makes recognizing the relationships between information nodes and keywords easy. Most visitors could create simple Venn diagrams and set related nodes into the diagrams after watching a simple demonstration. We observed that some users drew interesting Venn diagrams that resembled pictures. The system facilitates creative activities, so we expect users will be able to create more original, and increasingly effective drawings for information retrieval. Especially, we received good reactions from users regarding the combination of drawing and an image to create a Venn diagram. By exploiting such combinations, the system augments keyword searching, and it is different from conventional search engines [12, 13]. Moreover, combining keywords and user-drawn pictures to create Venn diagrams is possible.

Our system focuses on information retrieval for pen-based input. However, information retrieval using Venn diagrams is quite rough. We plan to combine our system with other types of sketch-based systems such as VelvetPath [16] to support more detailed interaction. With such a combination, users can use Catenaccio for general retrieval of information and then use VelvetPath to examine the information in more detail. In this case, all the manipulations would still be based on drawing or handwriting, so a user can handle a large amount of data in a natural way. Drawing manipulation is also useful for finger gestures.

Many AR systems support the use of finger gestures as an input method [17, 18]. As the system recognizes user finger gestures, users can create Venn diagrams by manipulating real-world objects, drawing circles, and writing keywords.

6. CONCLUSION

We described the Catenaccio system that is focused on Pen-based computing and allows users to retrieve information by drawing Venn diagrams. The system recognizes user writing and drawings (keywords and circles) and places information related to the keywords inside the circles. Using this input, the system provides an interactive and visual information retrieval method. We described some examples of retrieving information through simple drawings. We also provided several examples of unique Venn diagrams created by combining drawings with images and real-world information.

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