Concentric Ring View: An Interactive Environment for Integrating Searching and Browsing

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ABSTRACT
To find relevant information efficiently from a large amount of information, the integration of searching and browsing techniques is effective. This paper proposes a novice user interface that is based on a ring structure like a planisphere. The information considered in this paper is a set of information objects, each of them has multiple attributes. Without any keyboard typing, and using only a mouse, a user can choose appropriate search key or keys for each of the multiple attributes, and can easily filter information by adjusting keys. Retrieved results are displayed inside the rings, and the user can filter and browse them in real time. Therefore, a user can find the desired information even for ambiguous queries. In our technique, the reference conditions can be grasped immediately, and all types of attributes can be treated uniformly.

1. INTRODUCTION
Recently, the opportunities for ordinary people to treat large amounts of information are increasing, because of the popularization of personal computers. Searching based on keywords is frequently used in character-based interfaces. If a user can specify suitable keywords, this technique is effective. However, as the values of delicate changes such as shapes and colors are difficult to express in keywords, we must browse a lot of information to find our target. Browsing sometimes gives a lucky find, but generally takes time and labor.

For example, when a user specifies 'red' as a keyword, various red colors are displayed as candidates. If a user can describe the red color more specifically, candidates that have to be perused are narrowed down, so that browsing becomes easier. It is also better if conditions can be specified smoothly and the filtering and display of candidates can be performed in the same space in real time. We also realized that a user could find the relevant information efficiently if searching and browsing were carefully integrated.

Related tools integrating these two techniques include LensBar [1], FilmFinder [2], ZASH [3], and Cat-a-Cone [4]. They show two- or three-dimensional display and provide varied operations. Searching is performed using keys provided by the user with textfields, buttons or scrollbars, and browsing techniques include zooming, expanding a part, or connecting relational information. The following problems are found in these tools:

- the number of dimensions of an attribute is restricted, or is fixed,
- operations of conditional search are not unified,
- it is hard to grasp the information, or
- the operation itself is difficult.

In this paper, we solve these problems by using an interactive environment called Concentric Ring View that integrates searching and browsing. We have created a prototype image search system using this environment and conducted several experiments with this system, which is shown in Figure 1.

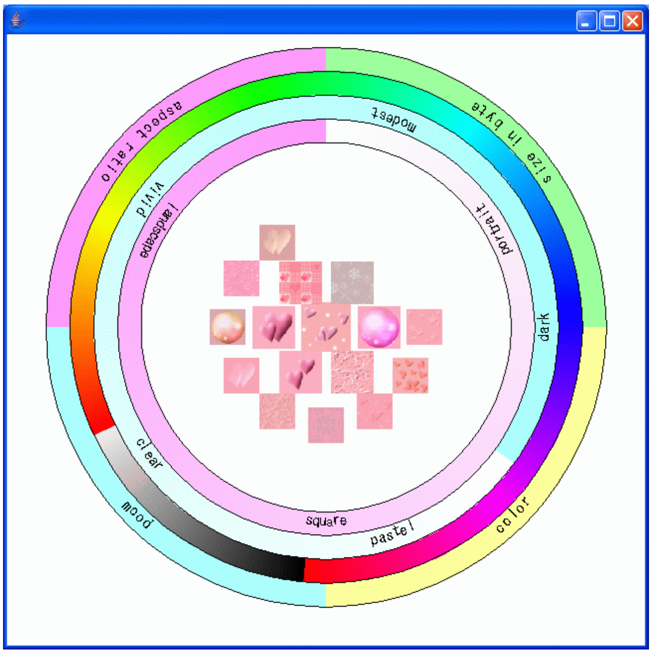


Figure 1. A screen shot of the prototype

2. CONCENTRIC RING VIEW

The goals of our technique are:

- multi-dimensional data can be treated,
- a user can retrieve information easily for an ambiguous query, and
- a simple and smooth interface, which beginners can also use without awful training.

The information considered in this research is a set of information objects that has multiple attributes such as an RDB. Attributes may be discrete, continuous, non-circular, or circular. Each data element has a value corresponding to each attribute. A user chooses a category on the basis of these attributes, and filters information by adjusting keys. For integrating searching and browsing, it is important that the Graphical User Interface (GUI) should operate without difficulty and presents a clear display of the information.

2.1 Graphical User Interface

A slide bar is usually used for fine control. This not only finely adjusts conditions, but also informs the user of the existence of keys. For instance, a user who is not familiar with digital cameras but wants to buy one may specify 200 million pixels as a keyword. Then, no result would be retrieved and the user would be confused. A slide bar could convey the information that there is no camera of such a high resolution.

However, a slide bar has a weakness for circulating quantities such as color. When the target value is located near the end of the bar, the user must move the knob many times from one end to the other. We therefore considered a ring structure like a planisphere for the GUI of our technique. The bottom part of a ring corresponds to the knob of a slide bar. The retrieved results are displayed inside rings, so that this structure does not fully utilize an ordinal square display device. We also considered a square structure instead of a circle. When we tried this on the prototype, however, we did not have a feeling of rotating circular quantities and also it was difficult to grasp the amount of movement. The GUI must be intuitive, so we chose a ring structure.

The outmost ring is a category ring. When it is clicked, another ring, called a key ring, appears inside. This key ring carries the keys that correspond to the category specified on the category ring. By rotating the key ring, a user can adjust the key and browse filtered results. By specifying more categories, other rings appear inside, and the displayed information is narrowed down. In this filtering, the outer key ring has the highest priority. The current key value is always shown at the bottom of each ring, so that the user can confirm the current position easily.

This technique allows users to specify search keys strictly and precisely. A user may not find desired objects because the specified keys are slightly different from the attributes the objects have. To overcome this problem, fuzzy matching is necessary for such application. In this system we implemented this function as follows, the number of candidates decreases naturally as key rings are added; therefore, the breadth of key values depends on the number of key rings if the key rings represent continuous quantities. For example, when a user specify only one key ring, the key value has a breadth of three degrees, and if a user adds another key ring, that becomes six degrees. The system can perform vague filtering automatically, without fine adjustments of keys by the user. If a key ring represents discrete data, the key value is always the bottom point of ring, to minimize confusion for the user.

2.2 Display of Candidates

Candidates are arranged according to the weight of a key and its priority. For the layout of this one-dimensional information inside a ring, we tried several alternatives: lines, concentric circles, or a spiral. Experiments using the prototype image search system showed that, when the candidates were displayed with sizes proportional to their importance, the alignment and spiral arrangements could display many candidates; however, users found the displays hard to understand. On the other hand, with the concentric circle layout, the center part looked raised, and the user did not feel overburdened. Therefore, we arrange the candidates on concentric circles based on their key values and their priorities. We also display the candidates that are closer to the center in larger sizes.

Zooming is often used for the display of detailed information. This technique is a way of looking through the whole and seeing detailed information, and so it is effective for information arranged in two dimensions. If we had used radius and angle to array information, we may have chosen zooming. In our technique, however, fine tuning, namely the continuity of the time-axis after filtering, is more important than the continuity of the screen space. Therefore, we chose a one-dimensional layout and details are displayed by putting a cursor on an image.

3. AN IMAGE SEARCH ENGINE

Using this technique, we constructed an image search system. The data to be searched consists of 10,195 free images designed for Web pages.

3.1 Construction

Four categories, color, atmosphere, ratio of height to width, and size, were prepared. They were obtained automatically from the images.

The color key expresses the feature color of the image, and can specify one or two colors for each image. If only hues were used, neither black nor white would be part of the index, which would leave a user puzzled if a black or white image was being sought. We therefore added a segment changing from white to black within the red segment in the color ring. Figure 2(a) shows examples of rotating color rings, and the rightmost example shows the specification of two colors.

The atmosphere key specifies whether an image is in pastel tones, clear or dark. The height-to-width ratio key specifies whether an image is landscape format, square, or portrait format. Figures 2(b) and (c) show examples of rotating each ring. It turns out that it is easy to adjust an atmosphere that could only be described with difficulty in words, or subtle shape differences that could not be expressed in a single term such as 'landscape format'. The last key, size, specifies the number of bytes of the image.

The system thus displays a maximum of five conditions at the same time. Then, because a user cannot see a candidate if it is displayed in an extremely small size, we displayed a maximum of 250, displaying a message to the user if there are more candidates.

Figure 3 shows a sequence of operations.

(a) The category ring is displayed on the initial screen.

(b) By clicking the category ring, a key ring appears inside and candidates filtered by the current key value are displayed.

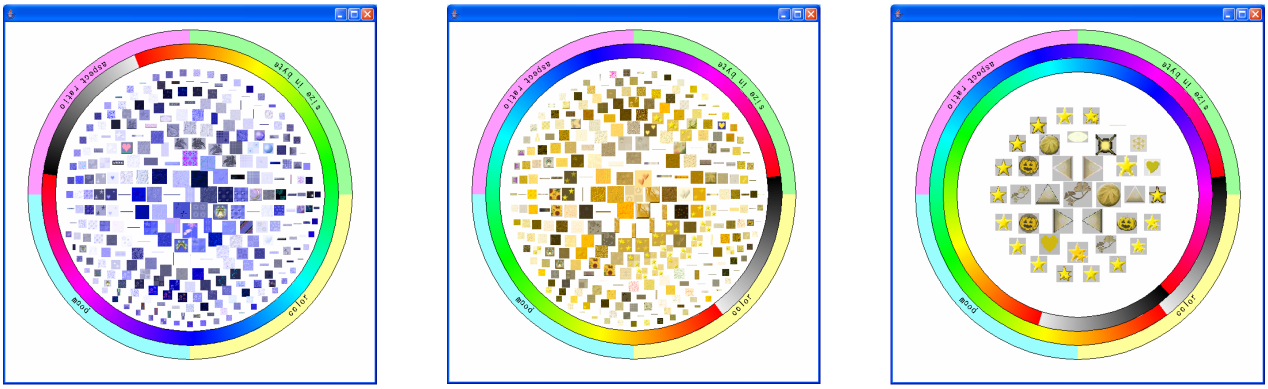
(c) The key is adjusted by rotating a mouse wheel after clicking it, or dragging the mouse.

(d) As more key rings are added, the candidates are narrowed down.

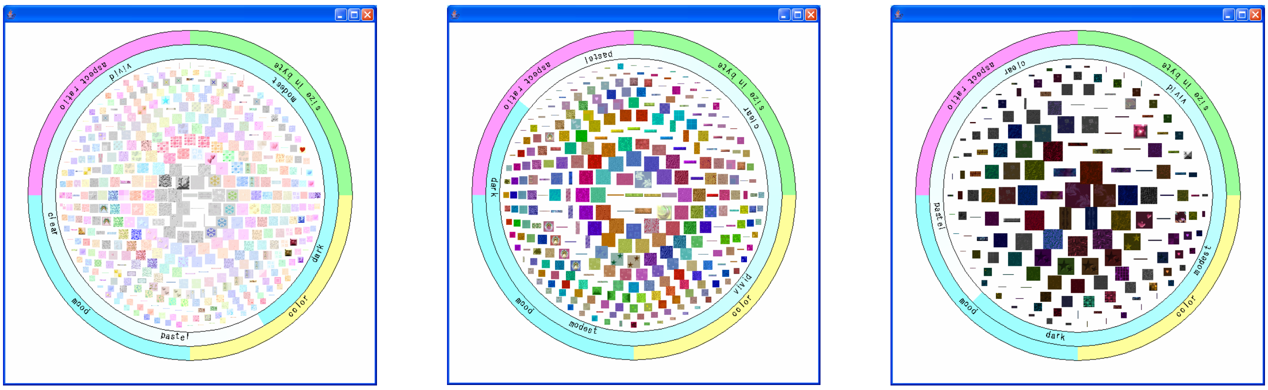
(e) If the cursor is put on an image, it is displayed at actual size.

(f) By clicking a key ring, it is deleted from the reference conditions.

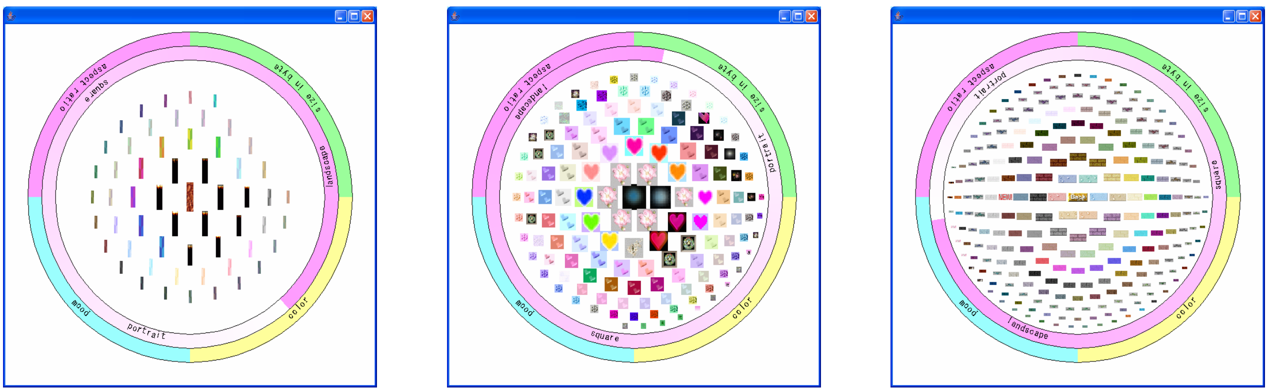
(g) Right clicking on a key ring exchanges it for the one next outside it, thus changing its priority.



(a) Color rings



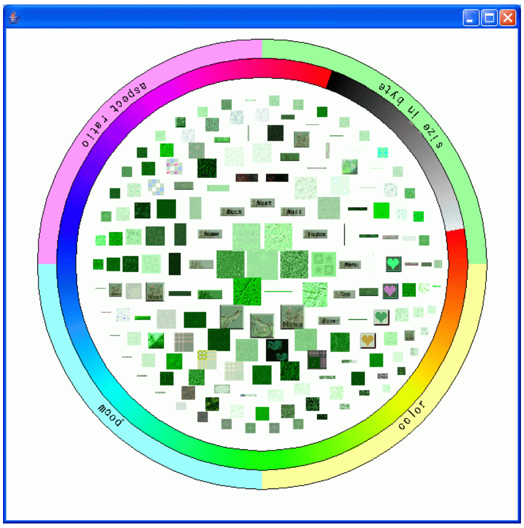
(b) Atmosphere rings



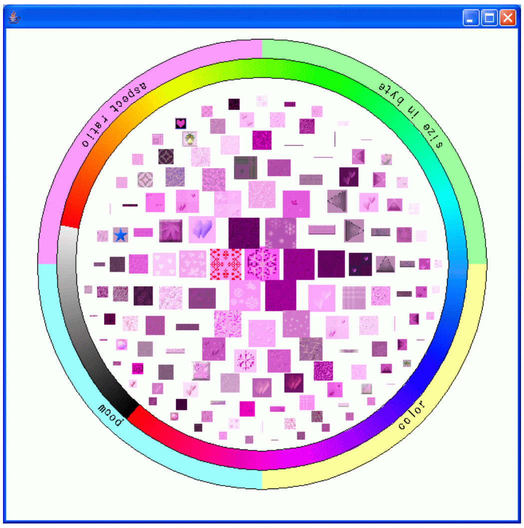
(c) Height-to-width ratio rings

Figure 2. Screen shots for rotating each ring

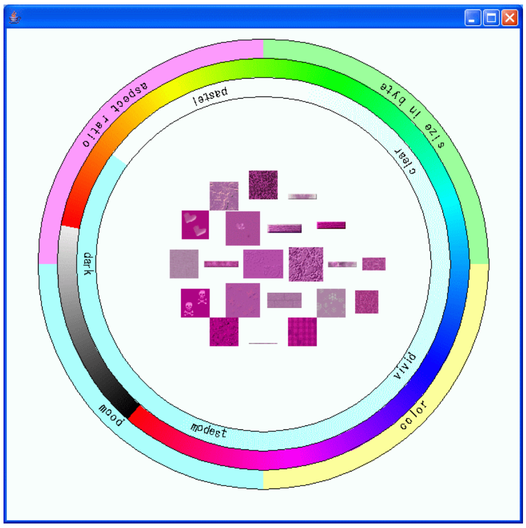
(a) Initial screen



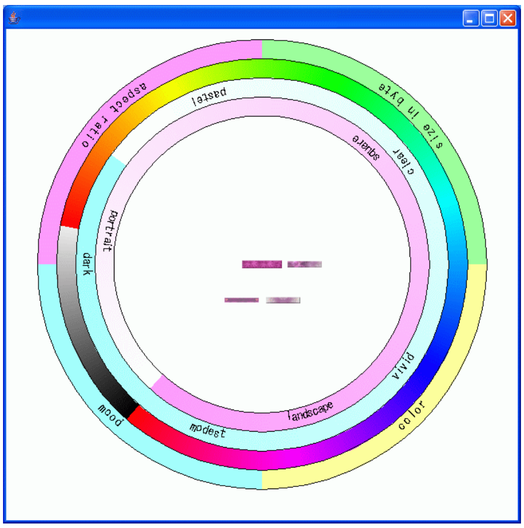
(b) Add a color ring



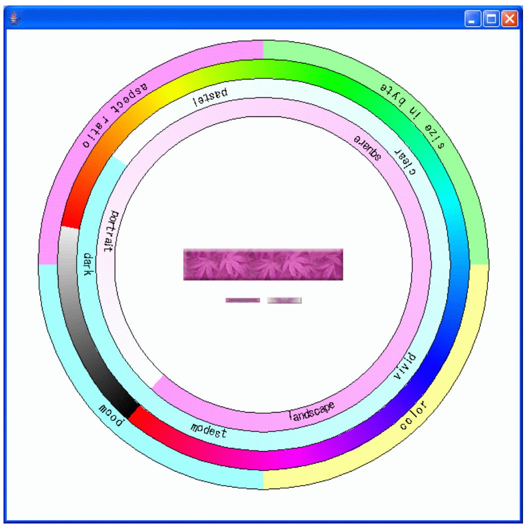
(c) Rotate a color ring



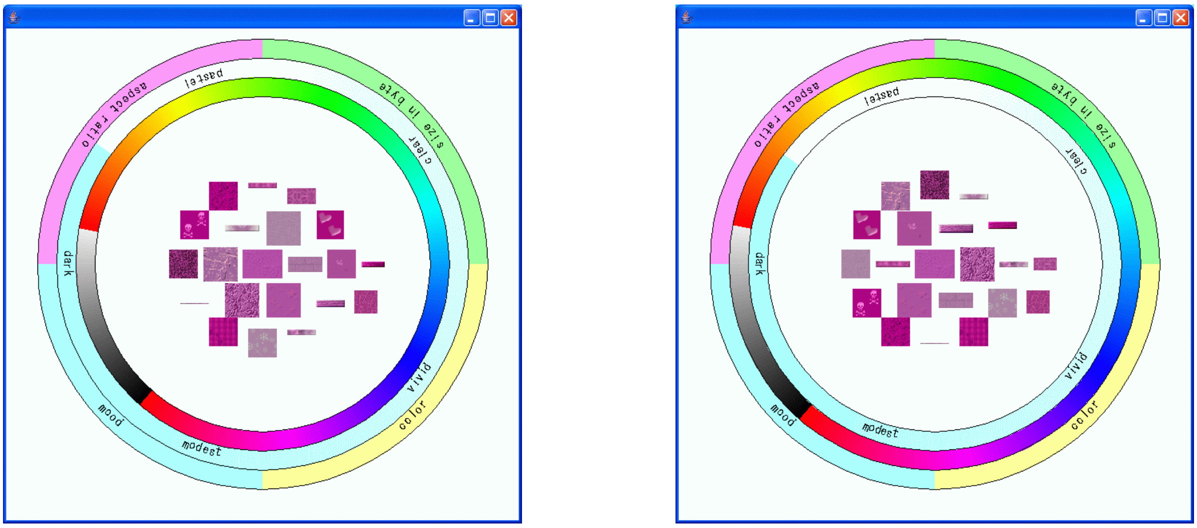
(d)-1 Add an atmosphere ring



(d)-2 Add a height-to-width ratio ring



(e) Put a cursor on the image



(f) Delete the height-to-width ratio ring **(g) Change the priority**

Figure 3. Sequence of operations (cont.)

3.2 Experiment

We recruited 18 test users: six beginners, six middle-class users, and six experts. We asked each user to perform the following three searches:

- find an image that is identical to a sample,
- find an image based on its description in characters, and
- find a set of similar images.

The last test was done only once, and others three times. Before the experiment, we explained the method of operation and users practiced for five minutes.

We determined that the end of each task is the time a test user chose the first image. The average search time for each experiment is shown in Figure 4. This shows that our technique is very effective even for a search based on the ambiguous information, because the keys can be controlled easily and candidate images can be browsed. Moreover, even the beginners obtained good scores in each experiment.

Users completed a questionnaire after the experiment, and all except one user answered that they felt the turning rings to be very natural. During their ring operations, five people looked at the lower part of the ring, 10 looked at the candidates in the ring, and three checked both. This shows that the users grasp changes of candidates intuitively, and filter without being conscious of keys.

Twelve users answered that it was easy to find an image from a description, and 14 said it was easy from a sample image. As this prototype supported only four categories obtained automatically from the images, it was relatively difficult for users to find useful key combinations. If keywords describing what was drawn in each image were available, searches would be even easier.

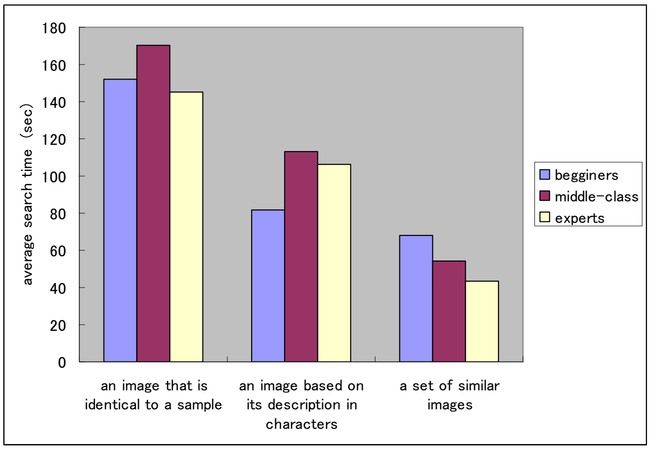


Figure 4. Search times in the experiment

4. CONCLUSIONS

This paper proposes the Concentric Ring View, which integrates searching and browsing. Candidates can be browsed while keys are adjusted; thus, fine adjustment of key values is simple. This technique can uniformly treat various types of data: discrete data such as words, non-circular continuous quantities such as shape or size, and circular continuous quantities such as colors and time of day. The ring structure adopted can treat attributes of three or higher dimensions. A user can grasp the current search condition easily because the selected key values and the priorities can always be seen at the bottom part of the rings.

A prototype image search system was implemented using this technique, and evaluated. It confirmed that users can find information efficiently for ambiguous conditions, and that beginners can select information as efficiently as experts.

5. FUTURE WORK

First, we must perform a more detailed usability evaluation. We should define the users' skill levels more carefully, and investigate whether beginners can truly master the system. Our experiment only allowed practice for five minutes, and so the relation with user experience was not considered. Therefore, we must study this further, and find how much practice is required before a user can perform fundamental tasks. We must also collect protocols for users' operations, because we think that this technique is not only useful for finding target information but also offers users new ways of thinking. Collecting such data is worth to try. This is because it seems that interesting results may be obtained; for example, different users may find the target with different key rings, and a user may change approach while searching.

Secondly, this prototype uses only continuous quantities as keys and, consequently, we should study the incorporation of discrete data. We must then address three problems relating to the area inside the rings. One is the displayed space, because it becomes small when a user chooses many keys simultaneously. Another is the number of candidates displayed, currently set at 250. The user may think of something suddenly from looking at small but numerous displays of candidates. We should consider cognitive studies for determining the adequate number of candidates to be displayed. The third problem is the way of displaying detailed information. An image is displayed at actual size when the cursor is put on it, so some images will be hidden behind it.

Finally, this technique cannot operate two or more key rings at the same time because the operations of adjusting keys in this prototype system are rotating a mouse wheel after clicking the wheel or dragging it. Because only one axis can be moved at a time, there are inevitably transitions that the user can never see. If several rings could be moved at once, it might help the user to find the target. We consider that a new input device that is rotated in real space might make this technique more intuitive.

6. ACKNOWLEDGMENTS

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