Navigation Tools for Text Embedded within Complex-Shaped Area Features and Meandering Linear Features

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Abstract: By presenting textual information within the space of corresponding images, the concept of DUAL-USE OF IMAGE SPACE (DUIS) eases the mental integration of textual and pictorial information. This paper applies the DUIS approach which was initially developed for area features to linear features. Moreover, we enhance the DUIS approach with new tools to navigate within embedded texts: The sidebar, the information petals and navigation bars. These tools provide the context as well as the structure of the entire textual information space at a glance thereby reducing the cognitive overheads associated with navigating within large texts.

Keywords: Dual-Use of Image Space, Area Features, Linear Features, Text Navigation, Information Sidebar, Information Daisy, Navigation Bar

1 Introduction

DUAL-USE OF IMAGE SPACE (DUIS) [CS02a] is a novel concept for integrating textual information associated with graphical objects into their own image space. The DUIS approach was developed for area features. This paper extends DUIS techniques to linear features like rivers and streets in cartography [RMM$^+$95] or the vascular system in anatomic illustrations. Readers benefit from the DUIS approach in the following ways:

1. **Spatial Contiguity:** DUIS minimizes the spatial distance between related textual and pictorial information. This enhances readers' ability to recognize co-referential relations [May01].
2. **Limited Screen Space:** This problem is exacerbated when images and their corresponding text explanations have to be displayed simultaneously. Most systems address this problem by scaling down the size of the presentations. However, the minimal font size to ensure the readability of text portions establish hard restrictions. By using the same physical space for both presentations, DUIS make wise use of this scarce resource.

However, even in the DUIS approach the space required to display textual information frequently surpasses the available space. In this paper we present new approaches for dealing with this problem. We describe new tools for navigating large amount of text displayed within complex-shaped area features and meandering linear features. These navigation tools indicate the relevance of displayed as well as hidden text portions with respect to interaction state and permit a quick and direct access to relevant text portions.

The remainder of this papers is organized as follows: In Section 2 we present a high-level overview of the DUIS concept. Section 3 discusses the application of DUIS on linear features. We discuss our new navigation tools and details of their implementation in Section 4. Related work is discussed in Section 5. Discussion and future work are presented in Section 6. Section 7 draws conclusions to this paper.

2 Dual-Use of Image Space

In DUIS the textual information related to a graphical object is displayed within the image space. From a technical point of view, the pixels in the image space represent both readable text and, at the same time, are used to shade graphical objects. In order to achieve an appropriate tone of graphical objects multiple font characteristics are adjusted in parallel.

Initial experiments reveal that even though subjects appreciate text presentations in the DUIS style they also criticize the text layout of the DUIS prototype. Test subjects find variations of font characteristics within the text display irritating. Moreover, glyphs of varying weight and width and irregular display background make the text presentation hard to read. To overcome this problem a new text rendering style, a more complex multi-column text layout algorithm as well as simplifications of the object's shape were developed.

Text Rendering Style: DUIS now incorporates two text presentation modes. The main objective of the *shading mode* (see Figure 1-left) is to reproduce the geometric properties as accurately as possible. Consequently, this negatively affects the readability of the text. In constrast, the *reading mode* (see Figure 1-right) might not maintain these geometric properties. In order to enhance the readability the tone is ignored. In addition, the object's shape can be simplified.

User interactions toggle between these modi: Objects are presented in shading mode unless the mouse rests over their projection. However, readers may *freeze* the presentation mode of objects. Subsequent user interaction do not affect the modi of frozen objects. This allows readers to access textual information for more than one object simultaneously or to compare textual information.

Irregular Display Background: The DUIS approach presents textual information within complex-shaped area features or linear features. These irregular-shaped text containers raise hard problems for an efficient and visually pleasing text layout algorithm. Since we are used to text presentation in rectangular windows this also affect the readability. In addition, the text lines may be interrupted which disturbs the normal reading process. The shape-related problems are addressed by either presenting the text in multiple columns or simplifying the object shape (bounding rectangle, convex-hull, global shape simplification). For a detailed discussion on distortion for readability refer to CHIGONA AND STROTHOTTE [CS02b, CS03].

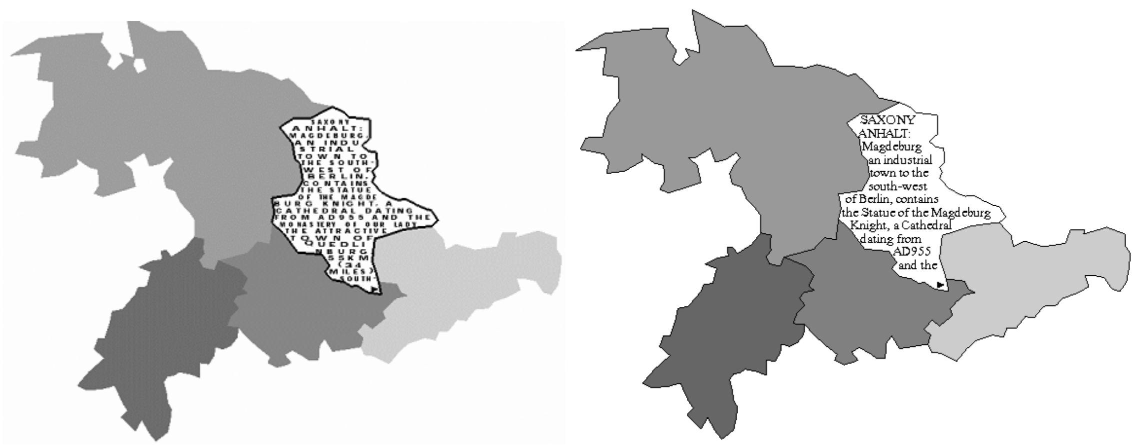

Figure 1: DUAL-USE OF IMAGE SPACE. Shading mode (left) and reading mode (right). The image in this example is a part of the map of Germany and the selected object is the state of Saxony-Anhalt. The arrow at the bottom of the text shows that there is more text after the current page.

Figure 2: Text rendering on branching linear features: Text is displayed on top of all branches (left) or only on main branches (right).

3 Application of DUIS to Linear Features

In comparison to area features which were addressed in the previous section, *linear features* have the following characteristics: (1) They may have branches, (2) they may join each other and (3) their 2D-projections can be self-intersecting.

Normal text presentation algorithms do not take these characteristics into account and consequently yield unpleasant results when applied on linear features. In addition, text layout algorithms for linear features have to consider additional requirements since the direction of text within or on linear features often depends on external parameters. In maps, for example, the direction of labels for rivers indicates the direction from the source to the end. To ensure readability of the text, however, this may be altered (see example in Figure 6).

Text layout algorithm for such objects is adapted from label placement techniques in cartography [WKvK+00] and artistic surface rendering algorithms in computer graphics [SE02]. However, ensuring readability of long texts presented in these objects is still an open problem.

We use a simple approach for branching objects: As displaying text on all branches makes it hard to convey the intended reading order, text is presented only on the main branch (see Figure 2). The object's name is displayed for all braches of branching objects in order to indicate the association. This is based on the gestalt principle: A similar visual appearance of objects indicates a common semantic classification. We apply *haloed-lines* techniques [ARS79] to intersecting lines: A line with a lower z-coordinate value stops some distance before the intersection and resumes some distance after the intersection.

Adapted distortion techniques for improving readability of text within complex-shaped area features also yield pleasant results for meandering linear features. Distortions can be either *contextual* or *overlay*. In contextual distortion all scene objects are displaced in order to get space for the distorted object. This preserves the context of the distorted object. In overlay distortion a newly created object is laid over the scene. It might displayed transparently to keep the underlying objects visible.

To ensure the users' comprehension, distortions should constrained as follows:

1. **Preserving Shape-Related Information:** The object's shape provides important hints to recognize and classify geometric objects. Thus, minimizing the distortion enables users to relate the distorted object with its original.
2. **Minimize Global Impact:** A distorted object which occupies a large amount of the available space influences the entire scene: It may displace the other objects ”too much” (in contextual distortion) or obscure ”too much” of the scene (in overlay distortion).

Distortion techniques for linear features can be categorized into two groups: (1) linear distortions and (2) areal distortions.

Linear Distortion: Applying linear distortions to linear features retain this classification (see Figure 3). We use the DOUGLAS-PEUKER line simplification algorithms [DP73] to obtain a line whose shape is more conducive to reading. The text is rendered on this line.

Areal Distortion: Areal distortions aim at creating 2D areas where text can be rendered. Distortion of the entire object shape violates the above mentioned constraints, instead, line segments are enlarged either into a

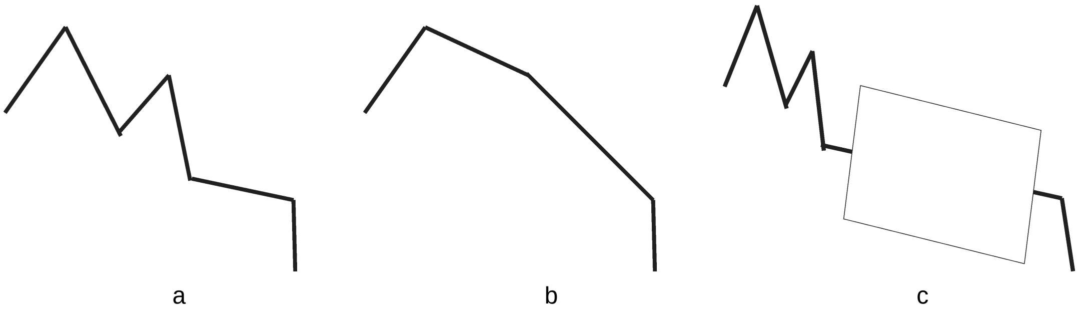

Figure 3: Distortions: Normal line (a), linear distortion (b) and areal distortion (c).

rectangle or into parallelogram (see Figure 3-c). A *distortion location function* determines line segments of linear features which should be distorted. This decision is based on the following factors:

1. The **current mouse position:** The distortion should be located as close as possible to the current focus area.
2. The **length and slope of a line:** To minimize overall impact of distortion to the scene, high priority values are assigned to line segments which require a small distortions.

4 Navigation Tools for Embedded Texts

DUIS deals with the problem of surplus text by use of (1) abstraction through folding and (2) arrows to show that there is extra information after or before the current page (see Figure 1 - 2). Invisible pages can be accessed by clicking on the respective arrows.

Both strategies suffer from various limitations: The *folding technique* requires the text to be hierarchically structured. Furthermore, the display of folded texts might exceed the available physical space. The *arrow approach* provides only rudimentary information: It only shows that there is more text available. However, it does not provide information about the structure and context of the entire information space. In addition, it allows readers only a sequential page by page movement through the information space, making navigation both time wasting and irritating since the user cannot jump directly to locations of interest.

Information on the overall text length, the position of the visible text portion in the text and its relevance with respect to the user's reading goals would significantly increase the usability of text navigation tools. This paper presents new navigation tools for text displayed within complex-shaped area features and meandering linear features: *sidebar*, *information daisy*, and the *navigation bar*. These tools display overview *and* relevance information on top of an abstracted outline of the object, thus enhancing a fast access to the textual information. The *overview aspect* indicates the relative position and the ratio of the visible text portion in relation to the entire document. The respective areas of these navigation tools are used to encode the *relevance* of the respective text portion with respect to interactively specified key words (as demonstrated in [Bjö01, JS98]) or systems hypothesis extracted from an automatic analysis of the interaction state [HS02].

4.1 Sidebars

Sidebars as used here extend the standard metaphor of scrollbars from rectangular to complex-shaped objects. They are either aligned to parts of the object's outline (*attached sidebar*) or constitute separate, but closely connected graphical objects (*floating sidebar*). Figure 4 presents the two alternatives.

The entire document is mapped on the sidebar using mural techniques [JS98, MC99]. A thumb-like object which overlays the sidebar encodes the size and the relative position of the visible portion of text. The colors inside the thumb are displayed brighter than the rest to enable users identify it easily.

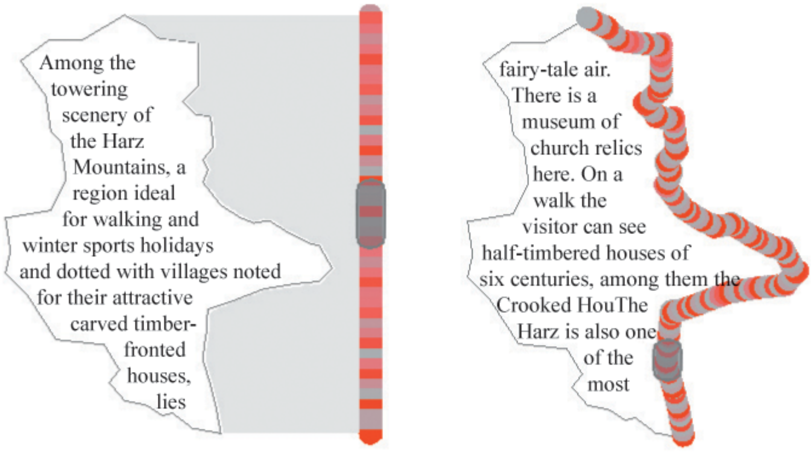

Figure 4: Floating (left) and attached sidebars (right) in DUIS.

An **attached sidebar** (Figure 4-right) is formed by broadening the outline of the object on one side of the object (either left or right). To ensure that the width of the bar is uniform, circles are rendered on the vertices to prevent gaps in the sidebar. By default, the bar connects the vertices with minimal and maximal y-coordinate value. Users can manipulate the length of the bar if they find it either too short or too long. However, to ensure clear identification of the start and end points, the two ends of the sidebar should never join.

The sidebar is usually placed to the right-hand side of an object. However, this may not always produce pleasant results for complex-shaped objects. We use a *sidebar-placement* function to decide the position of the sidebar. The sidebar placement decision depends on the number and the length of edges as well as the angles between edges. For example, consider Figure 5. The right-hand side of the graphical object is more irregular than the left-hand side. Consequently, the sidebar-placement function decided to place the sidebar on the left-hand side.

A **floating sidebar** (Figure 4-left) is attached to one side of the object's bounding box. A semi-transparent area ties the sidebar to the corresponding object.

4.2 Navigation Bar

Some application domains require displaying large amounts of text on linear features: The challenge is how to handle cases where there is more text than can fit on the physical space. Due to the irregular objects shapes,

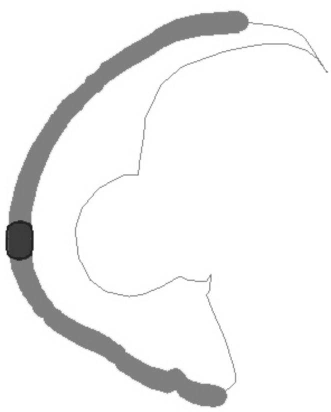

Figure 5: Weighting the alternative sides to attach a sidebar. The attachment of sidebars to right hand side would suffer from many sharp edges resulting in self-overlappings and gaps which have to be filled by circles.

standard text navigation tools like scrollbars cannot be applied. Therefore, we developed a set of navigation tools called *navigation bar* (see Figure 6). The entire text is mapped on the navigation bar. A transparent thumb indicates the relative position and size of the visible text portion within the document. Different portions of the text can be accessed by either clicking on the desired part of the navigation bar or dragging the thumb.

Using mural techniques [JS98] the background of the navigation bar visualizes the relevance of text portions in respect to interactively provided search words.

The navigation bar can either be *floating* or *underlying*. A floating navigation bar (Figure 6-d) is aligned along a more simplified version of the line. A transparent area is used to connect a floating navigation bar and its object. Underlying navigation bars (see Figure 6-c) are placed on the same line as the text. Normally, it is placed underneath the text. We have observed that this does not disturb the legibility of text since the bar is narrower than the text width and it is rendered in a faint color (see Figure 6). When a user is interested in viewing the details of the bar, they may bring it on top of the text (the bar can be made transparent and such the text would remain visible).

4.3 Information Daisy

In this new metaphor semi-circles or semi-ellipses convey information about individual text pages. The regular placement of the petal-like structures creates graphical objects which resemble daisy flowers. The petals serve the following functions:

1. They provide information on the relative position of the visible text fragment and the size of the document.
2. They show the relevance of respective document sections with respect to the current interaction state.
3. They allow a direct access to different parts of the document. Users access text portions by selecting a corresponding petal.

From a usability point of view it is necessary that the users should be able to do the following:

1. Identity the order of the petals (the first one and their direction).
2. Discriminate the petal for the visible portion of text from the rest.

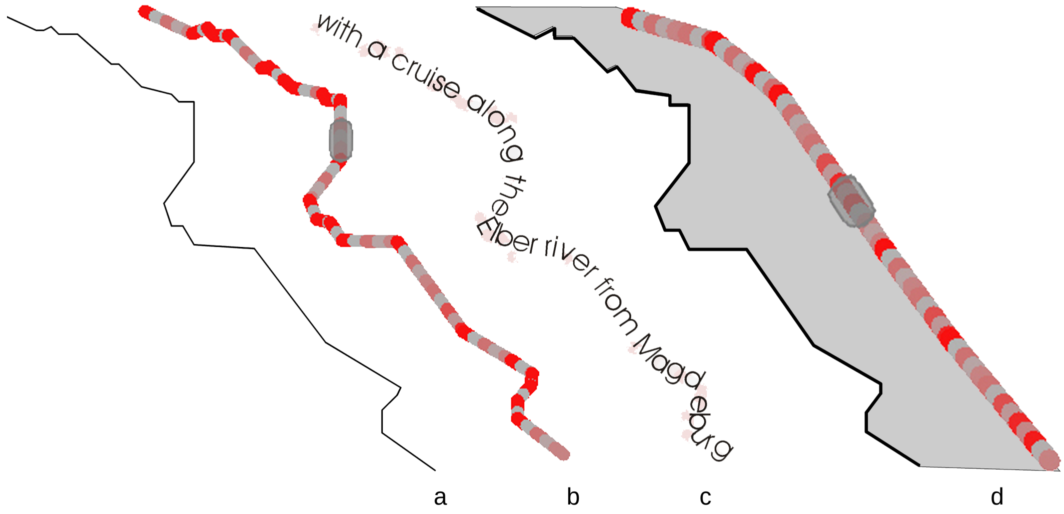

Figure 6: The Elbe river between Hamburg and Dresden (a). Underlying navigation bar without text (b) and navigation bar with text (c). Floating navigation bars for the Elbe: The navigation bar lies on a more simplified version of the objects shape (d). For simplicity, the line in (d) is provided without text.

The petals are ordered clock-wisely. As illustrated in Figure 7, a banner indicates both the start and the order of the petals. We use different edge styles, edge colors, and fill colors in order to emphasize the petal for the current page. Figure 7 uses different color encoding schemes for current and other petals.

Spatial Arrangement of Petals

The daisy metaphor requires a unique appearance of the petals. The petals are arranged around the object's center of gravity, adjacent petals share a bounding vector (i. e. the vector from the center of gravity to a end-point of the semi-circle). To ensure full visibility of the individual petals, the arrangement of petals satisfies the following requirements:

1. Petals, especially adjacent one, do not overlap each other.
2. The area of the semi-circle lies completely outside the polygon.

The radius of the semi-circles for the petals is constant. Variations in the radius, which may come due to the distance between the petal and the center of gravity may lead to wrong interpretations: Readers may interpret the length of the radius to have special meaning. The biggest danger, however, is that readers' perception of color intensity is partially affected by the area on which it is presented. As TUFTE [Tuf97] points out, the wider the area, the more dominant color presented is perceived. Petals could be superimposed like shingles (see Figure 7-middle).

4.4 Relevance and Color Encodings

Relevance information is color-coded using encoding schemes frequently used within information visualization [Ber67, Tuf97, War00]. We prefer color encodings where increasing intensities represent increasing attribute values. As shown in Figures 4 and 7, gray color represents text portions with low relevance, whereas red color indicates highly relevant text segments.

To measure the relevance in an interactive multi-modal presentation system the current interaction state have to be considered. In DUIS the interaction state of the graphical view is determined by (1) the object contained in the geometric model, (2) visibility information, and (3) information on the application of emphasis techniques and user selections. Based on a media-independent representation of domain concepts and relation, which is manually or automatically linked to graphical and multi-lingual textual representation, associations between most relevant objects can be determined (see HARTMANN [HS02]). This knowledge-based approach goes be-

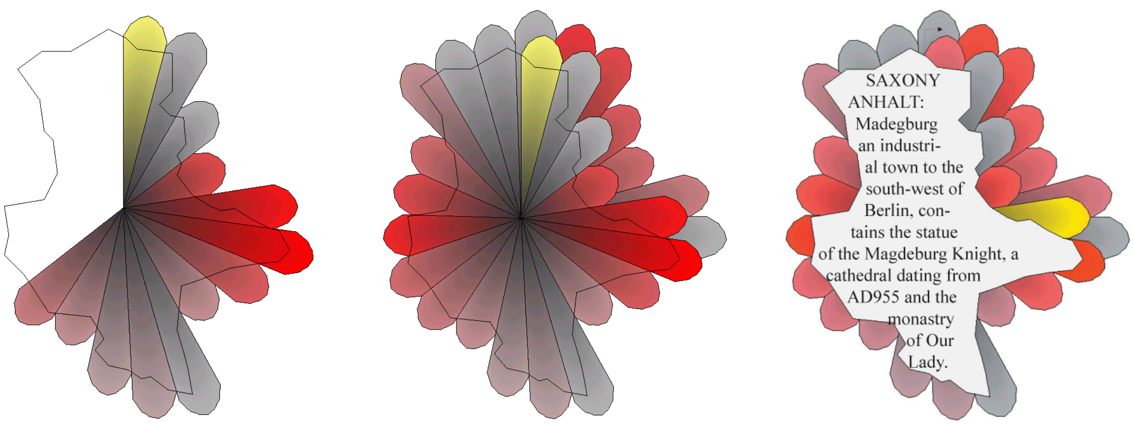

Figure 7: Information Daisies. The left and the middle illustration visualize the petal layout algorithm, whereas the right most illustration present their appearance within DUIS. The banner shows the starting point and direction of the petals (i.e. clockwise). The yellow petal represents the current visible page.

yond relevance measures based on the inverse term frequencies and term vector space techniques for matching queries and documents in information retrieval ([BYRN99]).

4.5 User Interaction

To avoid the navigation tools to occlude each other, only one graphical object should be enhanced with text navigation tools at a time. Thus, the navigation tools are provided only for objects when they are in focus (i. e. when the mouse is resting on the object). However, users may *freeze* a tool[1], that is, a frozen tool remains visible regardless of whether or not the object is in focus.

5 Related Work

The scrollbar is probably the most common tool for navigating through the text in long documents. The location and the size of the thumb provides information on the relative position as well as on the size of the document. However, the scrollbar does not provide further information beyond these basic functionalities.

A number of text documents navigating techniques providing more than the basic scrollbar functionalities have been developed. The INFORMATION MURAL [JS98] and the SCROLLSEARCHER [Bjö01] provide context information on the background of the scrollbar. In both systems the background of the scrollbar is used to display location of keywords. However, all these techniques have been developed for rectangular-shaped text containers and there is no obvious way of extending them to deal with complex-shaped objects.

TILEBARS [Hea95] uses bars to provide the relative locations of search words in a document. The bars are not placed in the document. While this approach does not take into account the shape of the text container, it requires a lot of space to display both the text and the bars. The space problem is exactly the problem which DUIS addresses.

The concept of information daisy is related to the concept of tabIndex in graphical user interfaces. In tabIndex an index of a page showing its name protrudes out and the pages are accessed by selecting a corresponding index. This metaphor (based on the manual thumb index) allows quick access to different parts of the interface. However, the tabs require a lot of space for very little information (just the name of the page). In addition, just like most text navigation tools, they are designed for rectangular-shaped objects.

6 Discussion and Future Work

The DUIS approach is well suited for information spaces which heavily refer to spatial aspects. Like many researchers (e. g. PREIM [PRS97]) who emphasize the importance of textual explanations of complex spatial configuration in technical and scientific text, we plan to apply the DUIS technique to illustrate anatomic textbooks and technical documentation. According to what we have observed in hand-drawn anatomy atlases, some text portions would have to be placed outside the object. We are considering to integrate textual labels of a varying level of detail as introduced in ZOOM ILLUSTRATOR [PRS97]. In this regard, we are faced with the following challenges:

1. The layout algorithms has to decide which textual information should be displayed within graphical objects and which one should be outside the object.
2. Co-referential relations between external textual labels and the embedded texts have to be established.

In the current implementation the radius of the petals of the information daisy depends on the length of the associated text segment. That is, each petal represents text portions of equal sizes. As we have noted (recall Section 4), petals can be layered when a single round of petals would not be sufficient. However, external

[1]The freezing of a navigation tool is independent of the freezing of the presentation mode.

requirements could impose restrictions on the usage of layered petals (e. g. due to space restrictions or familiarity). It may be necessary, therefore, to stick to one round of petals. Consequently, petals may be too small to display useful information for complex information spaces. To address this problem, we are currently working on applying fish-eye zooming techniques to information petals. While the spatial layout algorithm aims at an unique appearance of petals, the radius of fish-eye petals is adapted according to the relevance values, thus preserving more space for most relevant petals.

Finally, we are currently working on techniques to extend our tools visualize the results of multiple requests (as is the case in SCROLLSEARCHER [Bjö01] and TILEBARS [HEA95]). This could be done by creating stacked petals, which represents different aspects of the search result.

7 Conclusions

In this paper we have developed new techniques for providing text explanations for meandering linear features. We have presented new text navigation tools for text embedded in complex-shaped area features and meandering linear features: the information sidebars, information daisy, and navigation bar. These new tools provide more functionalities than what traditional scrollbars and than the previous DUIS navigation approach of arrows: They provide the structure and context of the entire document at a glance and they allow direct access to different parts of the document. Providing the relevance information on the navigation tool provide a strong coherence between searching and navigation thereby reducing the cognitive overheads which are associated in navigation. Application areas for these techniques include cartography and medical illustrations.

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