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Information Browsing via Diagram Displays

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Abstract

In visual information processing diagrams are frequently used for representing information. In large scale systems this results in very large diagrams and raises the questions of how to best display such diagrams on a computer screen and how to navigate around the diagrams. The aim of this research is to develop a system for automatic navigation of large diagrams. To display the diagram we are using a distortion oriented display technique. This shows the overall structure in outline form, but the particular area of interest in sufficient detail. Our navigation system is based on reasoning and making inferences. By automatic navigation we mean that the focused viewpoint is moved automatically along a navigation path. Using a clue set provided visually by the user the diagram is traversed following some navigation path. We are currently developing a prototype system.

Diagram Display Techniques

Information is commonly represented in the form of diagrams in a variety of application areas such as software engineering, databases, project management, artificial intelligence, project management, and computer networks. Some examples are data flow diagrams, state transition diagrams, flow charts, PERT charts, organization charts, Petri nets and entity-relationship diagrams. With modern graphics workstations, diagrams are used frequently in human-computer interaction.

Due to the relatively small size of a computer screen, a small portion only of a large diagram can be displayed. A facility to navigate to other areas of the diagram is a necessary part of an interactive visualization system. Current techniques, such as scrolling, paging and popup subwindows, show only part of the diagram and inevitably lose the user's 'mental map'. The main problem is that they do not provide adequate context to support navigation of the diagram.

Being able to see both the complete diagram and details are conflicting requirements of the user. This problem is generally referred to as the 'whole and detailed view problem' (Misue et al. 1994). To address this problem, distortion-oriented display techniques have been developed (Furnas 1986; Mackinlay, Robertson and Card 1991; Misue and Sugiyama 1991; Sarkar and Brown 1992; Leung and Apperley 1994). The main idea of these techniques is based on the perspective mapping method - a diagram is mapped to the screen with a whole outline and a local detailed viewpoint. Not only can a local area be examined in detail but also a global view of the diagram is presented at the same time to provide an overall context to support navigation. An example of a distortion-oriented display is shown in Figure 1.

In the development of these distortion oriented display techniques various approaches have been taken. Furnas (1986) proposed a method called the *Fisheye View*. The concept of the Fisheye View is to display a large object distorted as if through an optical fisheye lens. Mackinlay, Robertson and Card (1991) proposed a method called the *Perspective Wall.* Here a centre panel is used for detail and two perspective side panels for context.

We are more interested in the *Biform* display technique (Misue and Sugiyama 1991) which is to magnify the focus viewpoint uniformly and demagnify the surrounding area uniformly. One of its features is that it preserves the mental map of the diagram under the orthogonal ordering model (Eades et al. 1991; Misue et al. 1994). That is, it can preserve straightness of straight lines in the diagram. We have adopted the biform technique in our prototype system.

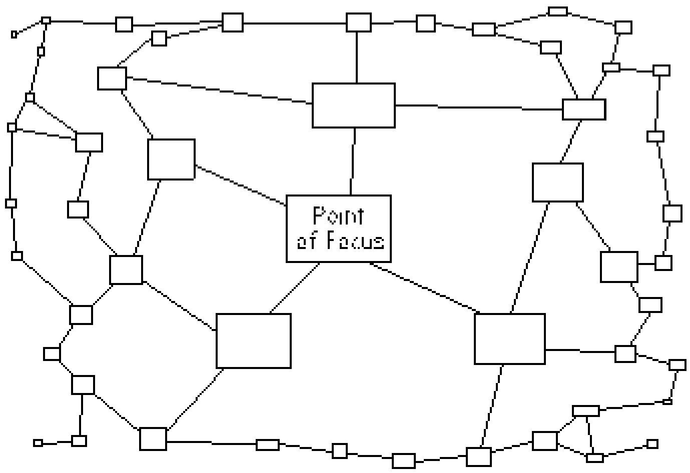

Figure 1: A distorted diagram display

Diagram Navigation

Our system for diagram navigation includes two major parts: (1) expansion of the point of focus, and (2) navigation to other points. The first part is achieved using the biform distortion-oriented display technique.

The second part is the process of diagram navigation which starts with a default node, or a node pointed to by the user with the mouse. From this starting node the point of focus moves to other nodes according to a navigation path. The navigation path is decided by reasoning a clue set *C* given by the user.

A clue is given by the user by clicking an edge linked to the current focused node in the diagram. A clue set *C* may include one or more clues. In our system, the left button of the mouse is used to select edges as clues, the right button of the mouse is used to indicate that a clue set selection is completed. After pressing the right button, a clue set *C* is formed. Based on the clue set *C*, a navigation path is decided by guessing the user's intention.

A very simple case is presented in the following example. The point of focus in the diagram shown in Figure 2 is the node 3. If the user selects only the edge (3,5) then the clue set *C* contains one clue. The system guesses that the user's intention is to do the *Depth-First Search* for graph traversal. The Depth-First Search algorithm is used to determine the navigation path. This path is as follows: *starting at 3: 3-5-7-1-2-4-6*. The navigation starts at node 3 and goes along the decided path. If this path does not satisfy the user, the traversal can be stopped by pressing the mouse button. The system then returns to the original status and the user can provide a new clue set.

There can be other navigation paths based on the same clue set. For example, if the user stops the current navigation and selects the edge (3,5) as the clue set again, the system guesses that the user is not happy with last navigation path and may want to do a *cyclic* traversal. The navigation path is: *starting at 3: 3-5-7-1-3*. The next time the user selects a similar clue set including one edge, the system may infer that the user would like to do a cyclic traversal.

The user may, for example, give the edge (1,3) as the clue set *C*. Based on the result of reasoning the user's intention last time, the system should infer that the user's intention is to do a cyclic traversal. However, the edge is an *input* edge (its arrowhead is pointing to node 3). Therefore, the system infers that the user's intention is to do an *inverse* cyclic traversal based on the inversion of edge directions (see the dashed lines in Figure 3). The navigation path is as follows: *starting at 3: 3-1-7-5-3*.

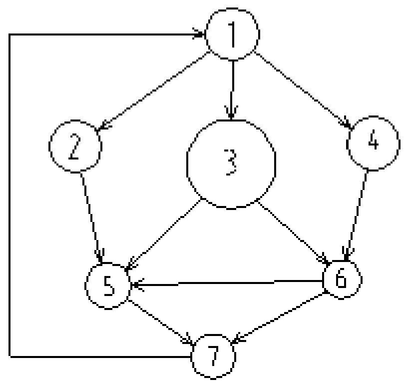

Figure 2. An example of diagram navigation

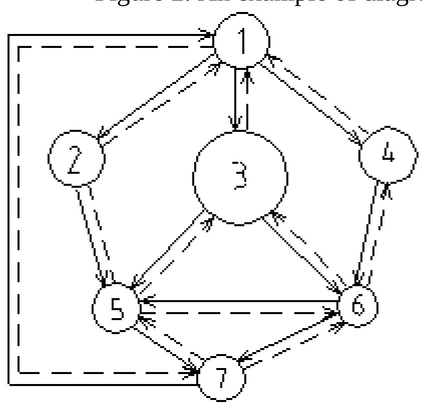

Figure 3. Inversion of edge directions

The *Inverse Depth-First Search* for graph traversal is also supported by the system. The navigation path decided by the Inverse Depth-First Search is as follows: *starting at 3: 3-1-7-5-2-6-4.* If the user gives two clues, the edges (3,5) and (3,6), for the clue set C, the system guesses that the user's intention is to do the *Breadth-First Search* for graph traversal. The navigation path determined by the Breadth-First Search algorithm is as follows: *starting at 3: 3-5-6-7-1-2-4.* Similarly, we have an *Inverse Breadth-First Search* algorithm. The navigation path determined by this algorithm is: *starting at 3: 3-1-7-5-6-2-4.*

The above search algorithms can also be applied to tree structures. The structure chart used in software development is a typical tree structure. The user can give the clue sets for the Depth-First Search or Breadth-First Search traversal of the module's children. A module's ancestors can be navigated by the Inverse Depth-First or Inverse Breadth-First traversal. The system also allows the user to navigate a diagram in a manual way by using the mouse to select a node as the point of focus.

Conclusion

Large diagrams often appear in information visualization applications. We are developing an automatic navigation system for viewing such diagrams. To display the diagram we are adopting a biform distortion technique. Our system can infer a navigation path based on the initial edges selected by the user. It calls upon its 'history' of inferred paths and adapts to the current situation.

Currently, we are implementing our design for use with a large information system. We are very encouraged with results to date from tests with relatively small diagrams.

We are very optimistic that our approach will produce good results with large scale systems. We believe that, with further development, our system will prove to be a very valuable tool.

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