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DISPLAYS

The next generation of graphical user interfaces: information visualization and better window management

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1. Introduction

To support the perceptually rich and information-abundant user interfaces of the future, displays must be larger with much higher resolution. With such displays, the worrisome flood of information can be turned into a productive river of knowledge.

Windows with 40–60 icons or scrolling lists with 20–40 items are inadequate for dealing with the complex tasks that users increasingly face. Advancing hardware, software, and networking technology have raised expectations for users of geographical information systems (GIS), 3-D graphics tools, information directories, scientific visualization, medical image databases, desktop publishing, programming environments, network management, video or animation editing, and other domains. These domain experts are motivated users who are attempting ambitious projects that demand rapid processing and access to large amounts of visual information, but unfortunately the window managers in graphical user interfaces (GUIs) have not kept up with the users' needs. Consequently, the advantages of large screens and fast displays are lost, leading to confusion, poor user performance, frustration, and missed opportunities.

2. User interfaces that future displays will need to support

Experience at the University of Maryland Human–Computer Interaction Laboratory (http://www.cs.umd.edu/projects/hcil) during the past five years has shown that visual query formulation and visual display of results can be combined with the successful strategies of direct manipulation. These include visibility of the world of action (objects and actions); rapid, incremental, and reversible operations; replacing typing by pointing; and continuous display as changes are made. Moving towards more visually oriented displays will better utilize the remarkable human perceptual skills. Based on this insight, we developed novel information visualization techniques such as dynamic queries, starfield displays, treemaps, treebrowsers, and widgets to present, search, browse, filter, and compare rich information spaces.

Dynamic queries are animated user-controlled displays that show information in response to movements of sliders, buttons, maps, or other widgets. For example, in the HomeFinder the users see points of light on a map representing homes for sale. As they shift sliders for the price, number of bedrooms, etc., the points of light come and go within 100 ms, offering a quick understanding of how many and where suitable homes are being sold. Clicking on a point of light produces a full description and, potentially, a picture of the house.

The starfield display was created for the FilmFinder (Fig. 1), which provided visual access to a database of films. The films were arranged as color coded rectangles along the x-axis by the production year and along the y-axis by popularity. Recent popular films are in the upper right hand corner. Zoombars (a variant of scroll bars) enable users to zoom-in in milliseconds on the desired region. When less than 25 films are on the screen, the film titles appear and when the users click on a film's colored rectangle, a dialog box appears giving full information and an image from the film. The commercial version of starfield displays will be available late in 1996 from IVEE Development (Fig. 2) (http://www.ivee.com).

In our LifeLines prototype (Fig. 3), we apply multiple timeline representations to personal histories such as medical records. Horizontal and vertical zooming, focusing, and filtering enable users to represent complex histories and support exploration by clicking on timelines to get detailed information. The entire display acts as a giant menu of selectable items to retrieve hundreds of displays of patient visits, X-rays, lab reports, and more.

3. Displays to match human vision and human abilities

Existing principles such as direct manipulation have been widely applied in word processors, spreadsheets, drawing tools, and many other environments. The benefits of direct manipulation are control/display integration to simplify

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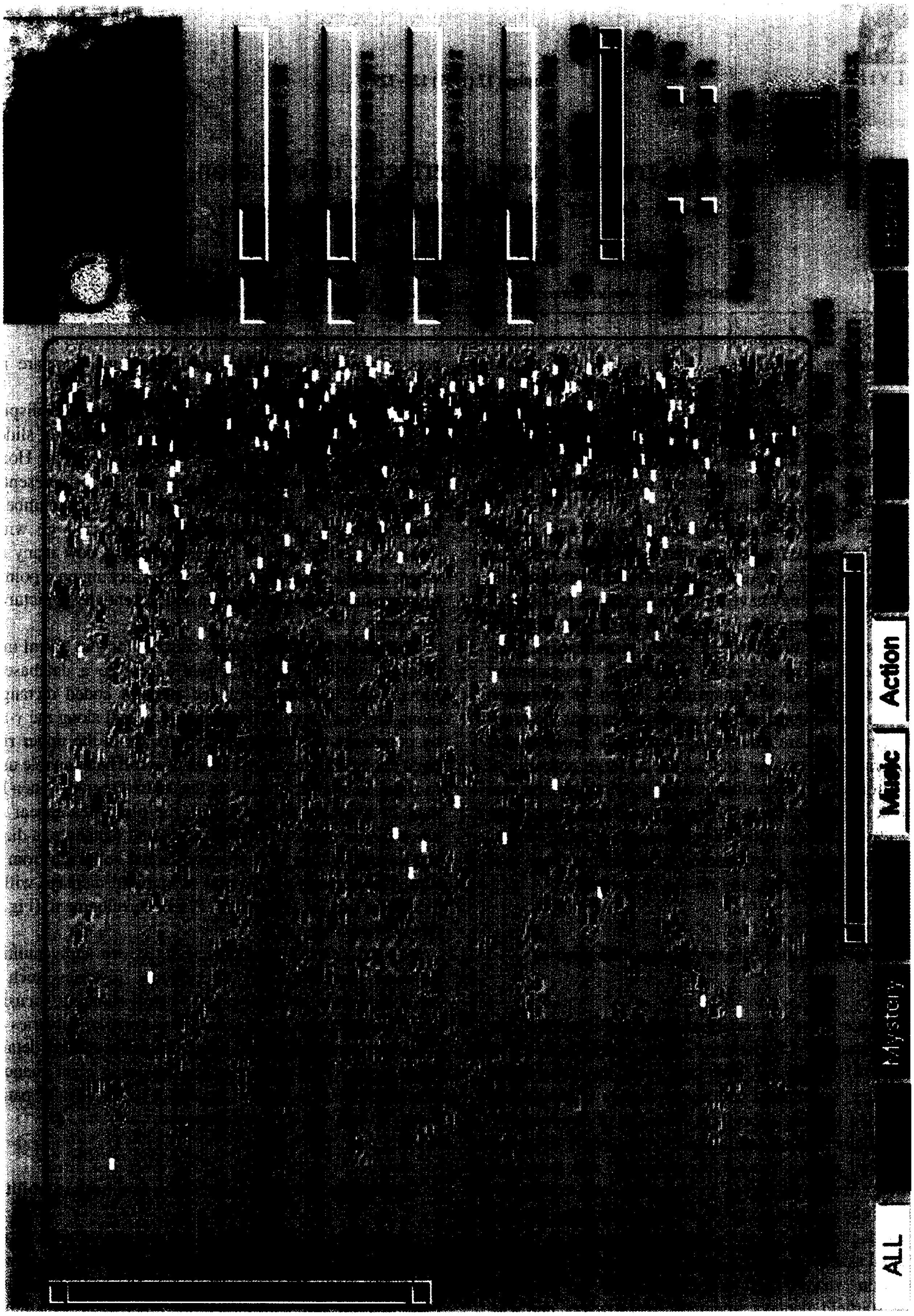

Fig. 1. Starfield display for FilmFinder.

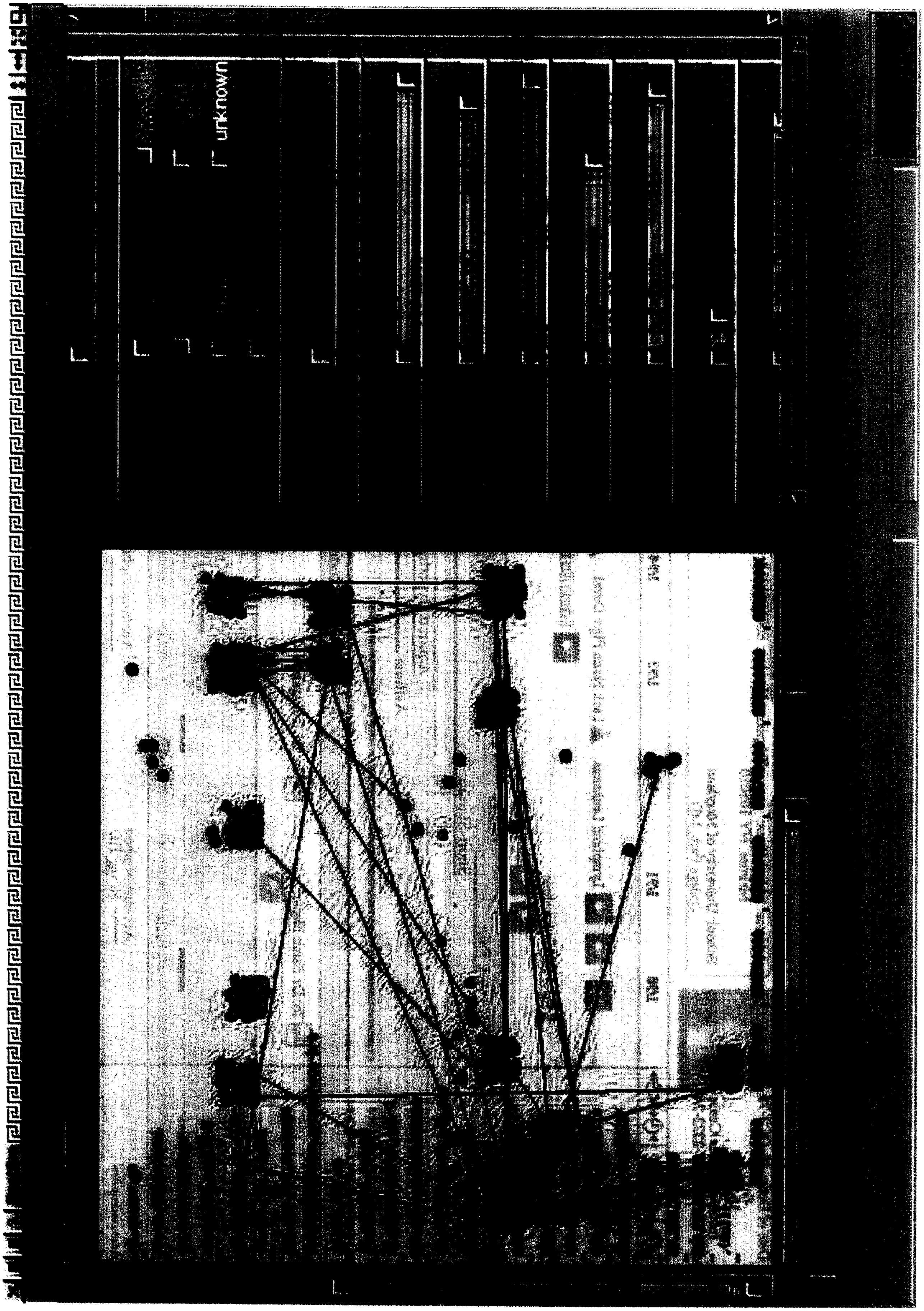

Fig. 2. Commercial version of the starfield display for FilmFinder.

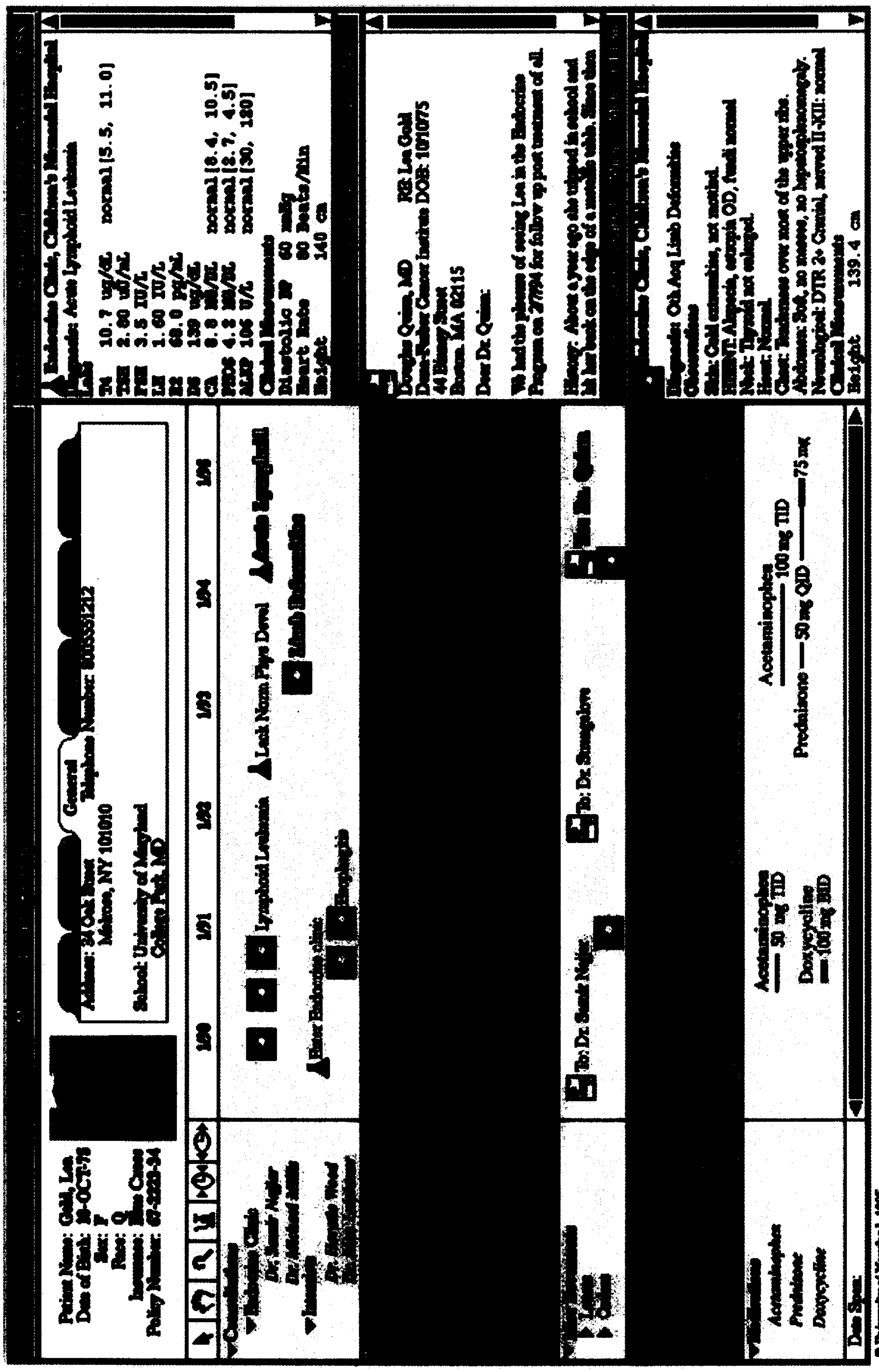

Fig. 3. LifeLines prototype.

usage and conserve screen space, and less syntax to reduce error rates, speed up learning and increase retention. Advanced information visualizations based upon these principles help to make the operation more comprehensible, predictable, and controllable, thus increasing the users' willingness to take responsibility for their actions. Of course, there are concerns such as the possible need for increased system resources, some actions may be cumbersome, macro techniques are still weak, history/tracing may be difficult, and visually impaired users have more difficulty.

As part of the movement towards more visual interfaces, there is a grand opportunity to create novel window managers. The computer industry appears to have inadvertently created a de facto standard based on 1984 era hardware and window managers (Macintosh, Windows, OS/2, Motif). This lack of innovation has left most users with the tedious job of manipulating one window at a time. Too much window housekeeping distracts them from their professional tasks and restricts what they can accomplish. The current overlapping independent windows paradigm has been shown to have problems, but viable improvements have been slow to emerge. I believe that important new commercial products and research avenues are open involving coordination across windows, multiple window operations, specification methods for dynamic systems, and improved visual information presentation.

Current GUIs are still quite primitive and poorly designed to take advantage of the remarkable human visual perceptual system and large, rapid, and high resolution computer displays. It seems increasingly archaic to see a small number of icons on the screen, deal with the cluttered desktop of overlapping windows, and waste time with unnecessary window housekeeping. Fortunately, appealing alternatives are beginning to appear in research prototypes. We propose Elastic Windows in which multi-window operations are achieved by issuing operations on a hierarchically organized group of windows in a space-filling tiled layout. We have developed multi-window operations to allow users to rapidly restructure their work environment. We claim that these multi-window operations and the tiled layout decrease the cognitive load on users. Users found our prototype system to be comprehensible and enjoyable as they playfully explored the way multiple windows are reshaped.

A second proposal is for Tightly Coupled Windows in which relationships between the contents of windows are easily specified and changed. Our designs replace operations on individual windows with coordinated operations that produce changes in several windows. For example, synchronized scrolling would allow users to specify two or more windows to be scrolled with only a single action. In hierarchical browsing, users can select a chapter title in a table of contents window, which will cause the full text to be scrolled to the selected chapter in a second window. Some of these benefits can be achieved through proper use of Netscape frames.

4. Conclusion

In information visualization, there are many alternative designs but the basic principle for browsing and searching might be summarized as the Visual Information Seeking Mantra:

> ''Overview first, zoom and filter, then details-on-demand''
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If we can design systems with effective visual displays, direct manipulation interfaces, and dynamic queries, then users will be able to responsibly and confidently take on even more ambitious tasks.

Similarly, in managing multiple windows, the Elastic Windows approach can reduce repetitive operations and permit users to take on more ambitious tasks that require 10–40 windows. Then users can benefit from Tightly Coupled Windows in which their intentions are more adequately represented. Undoubtedly, more principles and innovative designs will emerge as practitioners and researchers pursue advanced designs.