VISUALIZING LARGE HIERARCHIES WITH FOLIOMAPS: A BIRD´S EYE VIEW FOR PORTFOLIO MANAGEMENT

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ABSTRACT

The visualization technique of a TreeMap is applied to the arena of portfolio management via a prototype application. Designed to facilitate financial decision-making, the prototype provides a "bird's eye" view of large amounts of financial data and allows users to alter various aspects of the visual display dynamically. TreeMap concepts are illustrated via examples which reflect a real-world trading scenario.

1 INTRODUCTION

The electronic age has brought access to virtually every major stock exchange throughout the world right from the desktop computer terminal. Financial advisors and portfolio managers have the necessary information at their fingertips to maintain and trade larger portfolios more often and more efficiently then in the past. Every time more information is available, though, the requirement of effective handling and interpretation of this information must be satisfied.

Conventional mechanisms for dealing with large amounts of financial information include electronic ticker tape displays as well as character-based and graphical applications. These have proven quite useful for various tasks of portfolio management, but the ability to synthesize and present the volumes of information on portfolio stocks that is accumulated over even one trading day is a feature only a few of these tools support. The user is often forced to flip back and forth between screens and maintain distinct bits of information in his or her mind to accomplish the task of getting "the big picture."

2 PORTFOLIO MANAGEMENT TODAY

2.1 Portfolio Management And Organization

We are concerned here with the larger organizational hierarchies typically found in banks or brokerage houses. The lower levels of a hierarchy usually contain the portfolio managers or groups of managers, each group having a leader.

The portfolio managers are tasked with setting up and managing portfolios; they have a strong and direct relationship to the marketplace, the trading desk and their clients. But "Portfolio managers are not measured by how well they prepare but rather by how well they perform" (see Maginn 1983, pp. 7). So traditional task requirements for the portfolio managers are

- the ability to derive above-average returns for a given risk class and
- the ability to diversify (eliminate all unsystematic risk from the portfolio, Reilly 1985, pp. 678)

To properly evaluate the performance of the portfolios, a strong requirement exists for large amounts of data and computer systems to analyze these data.

2.2 Current Systems

Financial data is traditionally obtained through an electronic online "ticker" which is connected to the appropriate trading market. The task of portfolio management is performed by handling large printouts from the ticker, manual calculation on a form and/or manual data entry into a computer spreadsheet or database system.

Some more advanced systems provide direct links from spreadsheets or databases to the online ticker, making it easier to update the current value of the stocks in the portfolios. Others provide some additional portfolio setup and administrative functions such as generating portfolios, assigning them to portfolio managers, calculating their current values, and displaying data via line or bar charts.

Approximately 80% of those systems are implemented via character-based displays.

2.3 Current Problems

The online ticker system shows only character information, usually with *cryptic abbreviations* that are not ergonomically presented due to limited screen space. Data, steering and alert information are often not separated as distinct information classes and therefore are often mixed or not shown on screen. Comparing information must be done with a lot of back-and-forth paging, necessitating the use of pencil and paper in some cases. This causes *undesirable media-breaks*, *duplicate data entries* and loss of concentration on the task at hand. Exploratory information browsing, which involves posing various queries against the data (e.g., which stock's trading volume increased the most in the past week?), is a limited capability in most systems.

When it is present, this capability lacks *a visual presentation*, relying on the user to know a possibly cryptic query language and presenting results in a long list format.

Traditional graphic presentations like line and bar charts are useful for comparing and visualizing small amount of information; their benefits diminish when faced with the large amounts of data a portfolio manager must deal with daily. With tools provided currently, it is difficult for the user to have a complete *overview* of the current state of their hierarchy, locate "trouble spots" in massive amounts of data quickly, compare data, and visualize their data coherently.

Leading portfolio experts put their requirements this way: "Obviously, optimality with respect to a portfolio can only be achieved in a portfolio context. The monitoring and response process must therefore view the investor's assets as an integrated whole whose characteristics are evident and measurable (and therefore effectively addressable) only when seen as an entirety" (Maginn 1983, pp. 576).

Forming a portfolio strategy from data extracted out of traditional tools is *time-consuming* (Reilly 1985) and somewhat dangerous due to quickly changing data and market conditions. As a result the *monitoring task*, performance calculations, reports or portfolio strategies are often not done or appear delayed.

3 TREEMAPS AS A COMPONENT OF AN IMPROVED PORTFOLIO MANAGEMENT SYSTEM

For visualizing large hierarchies, the new TreeMap approach seems to be very promising so far for large scale applications like directory structures or product sales charting (Johnson 1991, Shneiderman 1991, Turo 1992). Our FolioMap implementation uses the TreeMap "Slice and Dice" algorithm for display (Turo 1992, pp. 2). It uses the same animation, zooming, node filtering and textual signpost techniques as described for the GE and the Unix directory prototype (Turo 1992). Also the design goals for the TreeMap concept are identical as described there for the FolioMap implementation. These goals are:

- space efficiency,
- interactive feedback,
- rapid information extraction,
- low cognitive load and
- esthetics (Johnson 1991, pp. 284).

4 FOLIOMAPS: PORTFOLIOS BECOME VISUAL

A prototype application was developed to address some of the problems discussed. This application, dubbed FolioMap, was developed on a Sun Microsystems Sparcstation 1+ under the OpenWindows 2.0 operating environment. The FolioMap prototype was used to analyze March 1992 New York Stock Exchange data for 150 selected companies, creating over 3,000 data points on which the TreeMap visualization was pinned. Each stock or fund analyzed included value, volume, delta value and volume from the previous trading day, performance relative to a selected portfolio value, and performance relative to standard market indices. FolioMap is dominated by a *TreeMap display* at the center of the screen.

The TreeMap is a visualization of both the management hierarchy and the portfolio hierarchy, combining the two at the portfolio level. The user is able to manipulate the diagram to provide different "views" of the data and selectively emphasize or de-emphasize objects on the screen. Flexibility of this type allows for a very customizable environment, with parameters set up to match users' individual objectives.

The *Feedback Area*, in the lower left of the window, provides one-way textual feedback on the current selected object. If this object is a lower-level stock, the base data is given along with the name and other items of interest.

If the selected item is an interior node, the values presented are aggregates of the children of that node. For example, if a portfolio manager is selected, the"value" would be the sum of all of the stock values in all the portfolios that person managed; the "delta-value" would be the change from the current summed value to yesterday's summed value.

The *User Control Area* on the lower right of the application's window provides the flexibility to completely control the look of the TreeMap. Size and color in the diagram, the degree of emphasis to be placed on the size attribute, and the offset space between hierarchy levels can all be manipulated. The user may *animate* the diagram over time

via a slider, and additionally may perform some querying based on special attributes or slider functions.

A *System Control Area* in the upper left, not implemented in the prototype, is the place to provide hooks from the system to the outside world -- input of files or data streams, output of files or graphic bitmaps, and connections to other systems.

5 FOLIOMAPS: TASK-DRIVEN VISUALIZATION

Imagine: it is end of the month and the branch manager of a medium-sized portfolio management unit is about to analyze last month's performance and the actions that have to be taken next month.

With the FolioMap visualization tool at hand, he will now first look at a complete overview of the performance of all portfolios in his branch segregated by portfolio managers, groups, and branch offices. With a few clicks on the sliders in the control area (Figure 1) he gets a quick hint that the March performance at portfolio manager level varies greatly.

Portfolio manager "D" is performing best, Group "3" with portfolio managers D and F exceed the competition and overall the Chicago branch is performing the best.

To evaluate what contributed to the success of Group 3, our branch manager zooms into Group 3 with another mouse click. He also expands the view to the categories level (figure 4), discovering that the categories mining and computers were good performers.

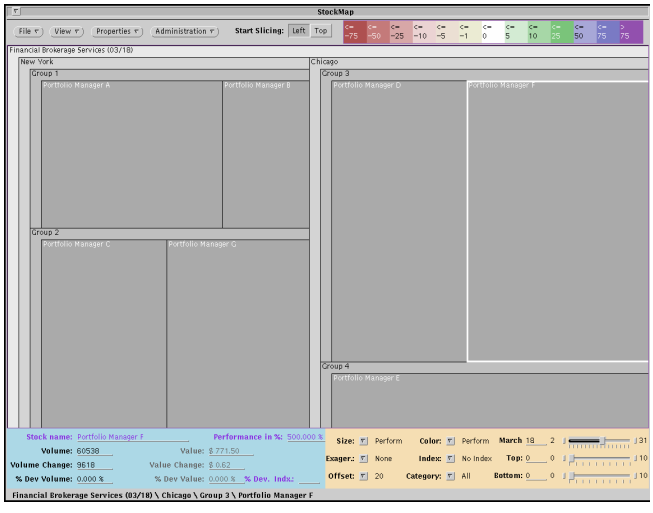

Figure 1: Complete performance overview of all portfolio managers. Slider settings: size is performance, color is view expanded to portfolio managers for March 31, offset 16, without zooming.

Expanding further to the stock level and zooming out to the complete overview (figure 2), he sees clearly that in Adobe and Sun Microsystems in the computers category are outstanding performers - while more mainframe-oriented computer companies such as DEC, IBM, NORSK DATA had contributed more to loss than to income and are therefore shown in red.

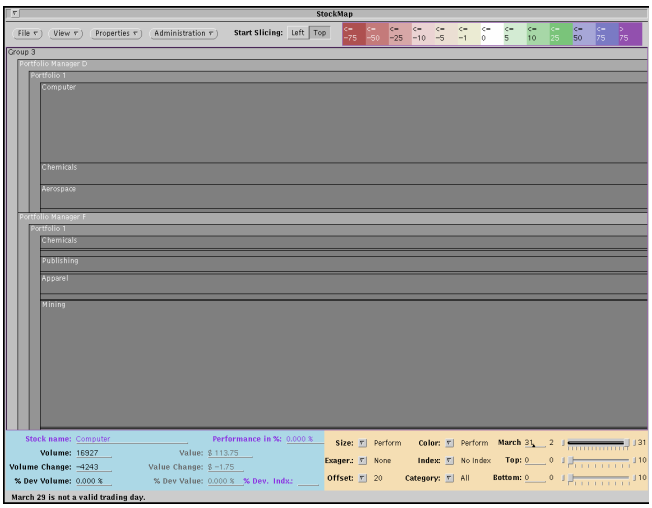

Figure 2: zooming to group 3, overview of all portfolio managers. Slider settings: size is portfolio units, color is performance, expanded view to categories for March 31, offset 16.

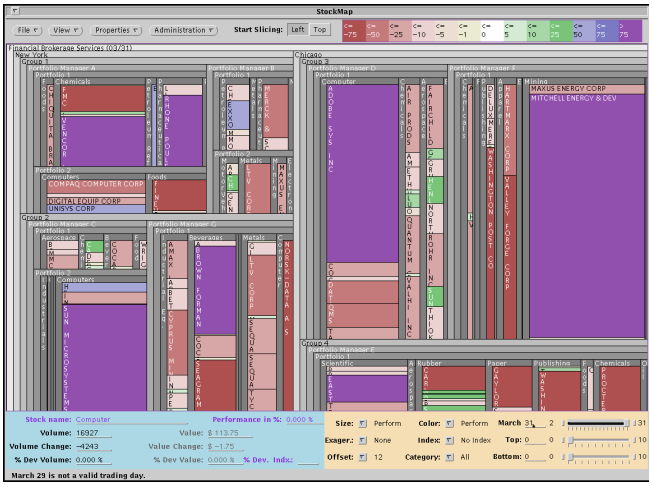

Figure 3: Complete performance overview of all branches. Slider settings: size and color are performance with expanded view to stocks for March 31, offset 16, no zooming.

If two rectangles appear in nearly the same size and/or have a different orientation (as are Adobe and Sun Microsytems in our example), it can sometimes be difficult to judge which is the bigger one (meaning better performance

in this case). It is therefore useful sometimes to "exaggerate" differences on the FolioMap; this is done via an exaggeration button on the control panel. Figure 4 displays the same data as in Figure 3 with exaggeration of size employed. It is now easy to see that Adobe has performed better than Sun Microsystems.

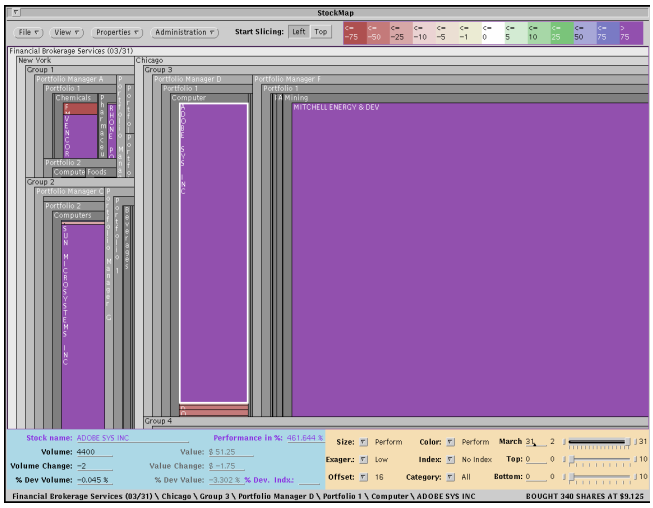

Figure 4: Complete overview over all branches. Slider settings: size and color are performance, expanded view to stocks for March 31 offset 16, exaggeration is set to low.

To compare the stability of the trend over the last month with these particular stocks, only a few "slides" can animate the diagram over time. This indicates that Adobe and Sun Microsystems have been good performers over the whole month and are therefore "stable" stocks -- at least for this time frame (Figure 5). Further investigation can be accomplished by adjusting the attributes that control size and color. Adobe may have performed well relative to the price we purchased it at -- but how stable is it in terms of the volume of shares traded during the month and its daily close-of-business value? Adjusting the size to volume and the color to value reveals that Adobe's value has changed only slightly and is now at a month low ($51.25) compared to March 2nd ($56.75). A perfect opportunity to buy now!

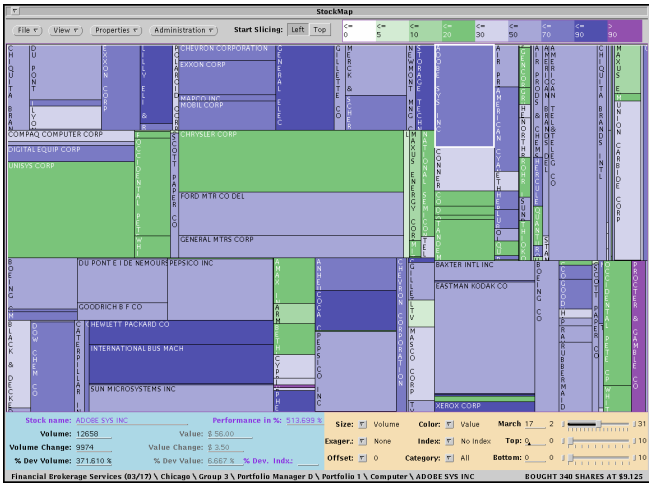

Figure 5: Complete value overview of all branches. Slider settings: size is volume units, color is value expanded view to stocks for March 17, offset 0, no zooming and exaggeration.

To discover when these portfolio managers should have been aware of these good opportunities, he tracks down the volume development. There were some high volume tradings around March 4 to 6 and March 17 which caused only small jumps in the value development (Figure 5).

Returning to his monthly report, the branch manager can now make some screen dumps of the important screens and include them as a proof together with the buying and selling recommendations of his subordinates. Of course, his personal experience and other information media and sources will add to the report as well. Taken as a whole, the FolioMap can be seen as providing the user with a visual display of large hierarchically-structured data that allows quick location of interesting areas. These areas may be further analyzed with the FolioMap or with other tools that may be linked to the FolioMap application. Mental information routing is thus optimized: the initial impact of massive amounts of data is minimized to allow the user to concentrate on particular details within the data.

6 INTERFACE INNOVATIONS: EXTENSIONS TO THE TREEMAP CONCEPT

To improve and enhance the basic TreeMap concept we made some specific extensions to our FolioMap implementation:

- *Revision of color design*
- *Exaggeration makes importance visible*
- *Increased flexibility and user customization*

Revision Of Color Design

Colors in computer displays are a complex and very important topic, yet they are also often preferred individually between different groups of people or users. This is also true for the color models used in finance, where green means positive action and red loss or negative numbers. So we revised the colors in that way, that the most important colors (shades of green/red) clearly pop out off a color reduced background, making it more easy to separate the important values from the "rest of the pack".

Exaggeration Makes Importance Visible

The aspect ratio problem with TreeMaps can mislead users in judging the area of a rectangle (Turo 1992, pp. 6). So it is sometimes difficult to decide which rectangle of two rectangles with different orientations is greater. To overcome these limitations, we implemented an exaggeration feature that allows a weighting algorithm (here implemented as the power of a number) to increase the difference between comparable areas (rectangles). The usability advantage of this algorithm is reducing the number of rectangles shown on screen by increasing their size, so leading to quicker judgments and decisions.

Increased Flexibility And User Customization

Flexible variable assignment: According to the kind of query - selected as conditions through sliders (dynamic queries) at the bottom panel - size and color of the rectangles can vary. So far TreeMaps have had only fixed coded variable assignment. Size and color of the rectangle can now be assigned independently from each other to the financial values, giving users a very flexible tool to accomplish every specific query task according to their perception ability and preferences.

Improved comparisons and navigation: Zooming techniques in and out to different levels of hierarchical information have already been implemented into a TreeMap display system (Johnson 1991). As the needs to compare different portfolios against each other become more and more important, we decided to implement an additional *split window* technique. A *blend out* feature makes it possible to show just the information which is needed to avoid the "information overkill", which can occur if the information space is too dense and too many variables are assigned. With the "blend out" feature information is presented in layers and users can unwrap one layer after another or just show one layer. This unwrapping is done by just selecting a menu command and is actually hierarchy dependent.

Better Labeling: The optional label within each rectangle allows quick identification of the stock type as well as the string label in the bottom left area allows to read precise financial values of the selected stock.

7 ISSUES AND FUTURE DIRECTIONS

Color blindness: As a significant amount of people are colorblind to a certain degree, it is important to notice that our prototype is based mainly on color perception. To overcome problems with color blindness it would be possible to display black and white gray scales and patterns. Probably they can be set up optionally, in case a colorblind person has difficulties and needs some better clues to figure out the actual value of a color.

Additional filtering techniques The dynamic sliders at the bottom control panel of the FolioMap display are actually dynamic queries (Williamson 1992) - but have no filtering power, as the whole data are always displayed in a different calculation algorithm. If a user is seeking for a special value or stock name and wants a graphical feedback for all the locations of that particular name, a different tool needs to be developed. So it would be nice to have the text display field in the lower left corner of the screen enterable. Users could enter here a string or a number to search for, hit the enter key and get back the whole screen display with the highlighted rectangles matching the specified criteria (for example a red stripe pattern could be used to distinguish it from the rest of the display).

Graphical sorting techniques : A possible solution for the aspect ratio problem besides weighting exaggeration algorithms is sorting. Sorting for the size of a rectangle helps ease the decision making, because the mental size decoding process is backed up by following a size - sort order of rectangles within a parent node. We implemented this feature - also optionally switchable - to help overcome the uncomfortable feeling some users had that the graphical display is not precise enough (Turo 1992, pp. 8).

Direct manipulative color boundaries: In stock trading stock values sometimes reveal only slight changes (less than 1 percent), while others change dramatically with a 2 digit growth. To give the user a better and more individualized control over the display it became apparent, that it would be nice to have a direct manipulative tool for assigning colors to display ranges. A mouse click on any of the color label rectangles in the menubar could open a palette, where the users can immediately choose their preferred color. Ranges could be assigned through double clicks opening a dialog box for specifying parameters.

Translucent data overlays: In addition to the improvement of conventional labeling techniques one can imagine that translucent overlay techniques - especially for textual overlays could be a powerful extension to the TreeMap display. Translucent windows or data layers, as

introduced to the HCI community by Ishii (Ishii 1991), solve the problem of small screen space by providing overlapping displays, increasing the density of the display. Still unendeavored for categorical data display - Ishii experiments are done with video overlays - this innovative technique needs careful design and evaluation.

Texture coding: TreeMaps have potential as multivariate exploratory data analysis tools (Turo 1992, pp. 7). As so far only a two-variate display is implemented (variables assigned to either size or color) it is conceivable to increase information density with texture coding. Textures as a third variable could be the background of each rectangle and could help distinguish more complex data. In a FolioMap portfolio environment, size coding could be used for actual bundle sizes of securities within a portfolio, color for profit or loss (performance) while texture could be assigned to the kind of securities (asset allocation) or customers.

Contour coding and time series: Still unused for coding information (assigned variable values) are the FolioMap rectangle borders or contours. Their thickness could vary and so carry information of a third variable besides size and color variations.

Information overload: As the density of information on one single display increases with methods like translucent displays, contour and texture coding, the danger of information overload increases. Therefore a careful and immediate usability testing is a necessity to avoid these pitfalls.

Direct manipulative rectangle handling: As portfolio management systems usually not only reveal the need for continuous data updates, but also for easy handling of portfolio setups, stock bundle assignments and hierarchical organizational information (such as manager assignment etc.). We are considering ways to grab a certain rectangle (or groups of them) and add, delete or move them around the screen with immediate display updates. This would greatly enhance the usability of the application, especially for real time trading situations.

7 CONCLUSION

Although usability data is available for TreeMaps (Turo 1992, pp. 8ff) indicating major advantages in comparison to conventional displays and listings, a usability study of our prototype is still to be done. We will continue our work with usability testing to prove the actual likes and dislikes of professional users as well as to find out the best solutions for the display appearance.

The FolioMap application clearly showed the enormous potential of tools like TreeMaps for exploring very large information spaces. Yet there are still many research opportunities for concept enhancements.

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