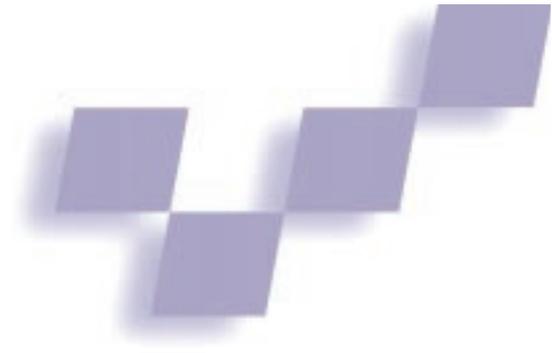


# Information Visualization Applications in the Real World



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Information visualization has many practical applications. This ability to solve real-world problems is one of its main attractions. Modern systems can be extremely complex, and information visualization is one tool to help users overcome this complexity. We have already seen some encouraging beginnings in the commercial sector realizing this vision.

This section presents some key examples of people

applying information visualization to solve real-world problems in business and other applications areas. These include the financial market (Wright, Visible Decisions), user interfaces and Web browsers (Rao, InXight), software maintenance (Fyock, Lucent Technologies' Visual Insights), and data mining (Becker, Silicon Graphics). We expect this trend to grow in the next few years, promising to make information visualization a key technology in tomorrow's market. ■

# Business Visualization Applications



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Three-dimensional computer graphics can be extremely expressive. With the correct approach to a layout's visual design, people can quickly and easily comprehend large amounts of information. You can convey far more information in 3D than with 2D bar charts, or rows and columns of numbers. This article provides examples of information visualization applications in several industries, including the capital markets, retail banking, manufacturing, and consumer product goods. These examples help show what it means to put abstract information in 3D and what benefits result.

The following examples were

implemented on Unix workstations with entry-level 3D acceleration and on Pentium Pro Windows machines with some 3D acceleration. All the graphic representations can be animated at three or four frames per second (that is, the properties change as time is played back). The applications also support dynamic sorting, drill down, and filters.

## Fixed income risk management

The first example is fixed income portfolio management. Figure 1 shows more than 3,000 bonds on a single screen, with long positions in green and short positions in pink. The height shows the value of the bonds. The left axis shows subportfolios. The front axis represents the bonds' time to maturity. A total line, located along the front of the landscape, adds the subportfolios. At the rear is a yield curve (that is, interest rates)

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**Example visualization applications for business demonstrate their frequent emphasis on 3D representations and the benefits they provide.**

based on a set of benchmarks. Figure 1 displays the profit and loss for each position for a yield curve shift scenario. Other models of asset value can also be displayed.

Users can point at one of the positions and retrieve numerical and textual details related to that position's size, issue, and issuer. While visual perception quickly yields anomalies and patterns, to obtain the necessary detailed data, users must be able to point at objects and get the numerical and textual data behind them. This technique, called brushing, is an important requirement for information visualization applications.<sup>1</sup>

Animation is used in this landscape to help assess market risk—risk due to a change in interest rates. Users can move the yield curve to see the effect on the portfolio's projected profit and loss. As the curve moves, values change by increasing or decreasing in size. Users can quickly see where the portfolio is hedged—that is, insensitive to changes in rates—or where it is exposed and by what degree. The scenario profit and loss calculations occur rapidly, so the profit and loss changes interactively with changes in the yield curve.

Users can interact with this landscape in several ways. You can select one or several bond issuers from a list of all issuers. The corresponding positions in these issues are then highlighted within the portfolio so that you can see what is held and where it is held. Another type of query, a filter based on size of position, is implemented using a slider bar. Users filter out small long and short positions so that the landscape displays only large magnitude positions.

Compare this risk-viewing landscape to a conventional on-line system that displays 20 to 40 positions per screen. This 3D landscape shows 3,000 or more positions per screen. Using query and filtering, you can highlight patterns possibly hidden in a numerical display. A 3D visual approach provides more insight in minutes than traditional computer numerical displays could provide in hours.

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### Derivatives risk management

Figure 2 shows a screen from a fixed income options trading and tactical risk management system. In the derivatives market, the instruments being traded and their interrelationships have become increasingly complicated in recent years. Visualization helps manage this complexity by presenting various event and relation-

ship-related information in an intuitive, meaningful, and flexible manner.

The objective is to give traders the ability to aggregate, display, and manipulate as much financial data as they require to make quick and informed trading decisions about how to mitigate the risk on their portfolios of options. Traders must be able to quickly and easily see exposures (profit and loss) to scenarios and the nature of those exposures, based on derivatives pricing parameters.

At the left rear of the 3D display you see a yield curve and scenario curve. Users can manipulate the scenario curve to look at twists, parallel movements, or arbitrary movements. What happens if interest rates go up or down? Shifting the curve results in immediate changes to the adjacent surface map and grid chart. The surface map shows current and scenario profit and loss. The grid map shows relative profit and loss (that is, the difference between the current and scenario situations).

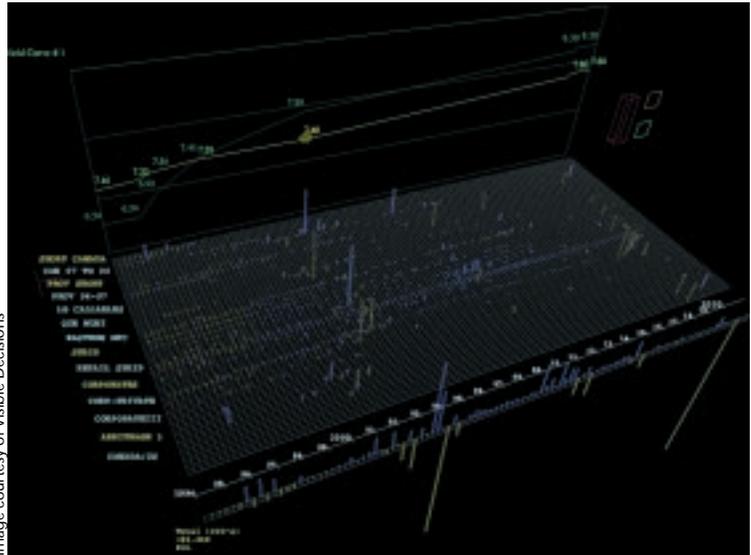


Image courtesy of Visible Decisions

1 3D visualization of a fixed income portfolio.

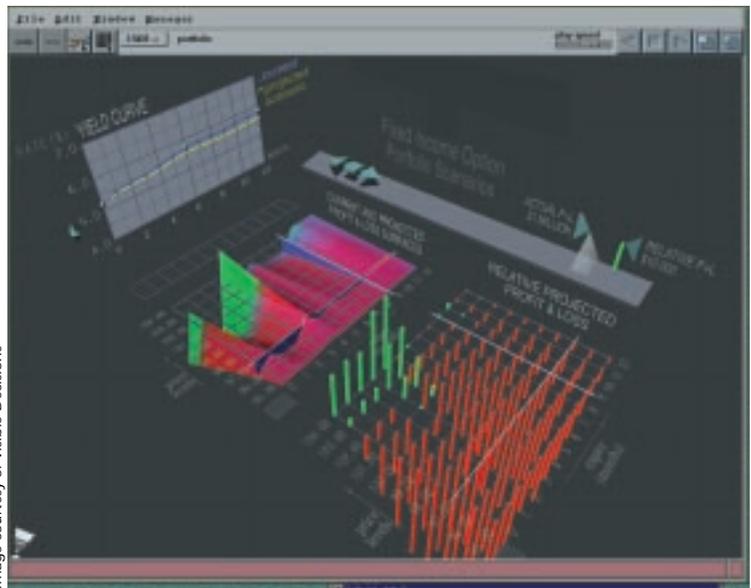


Image courtesy of Visible Decisions

2 A 3D fixed income options trading and tactical risk management system.

3 Management decision support.

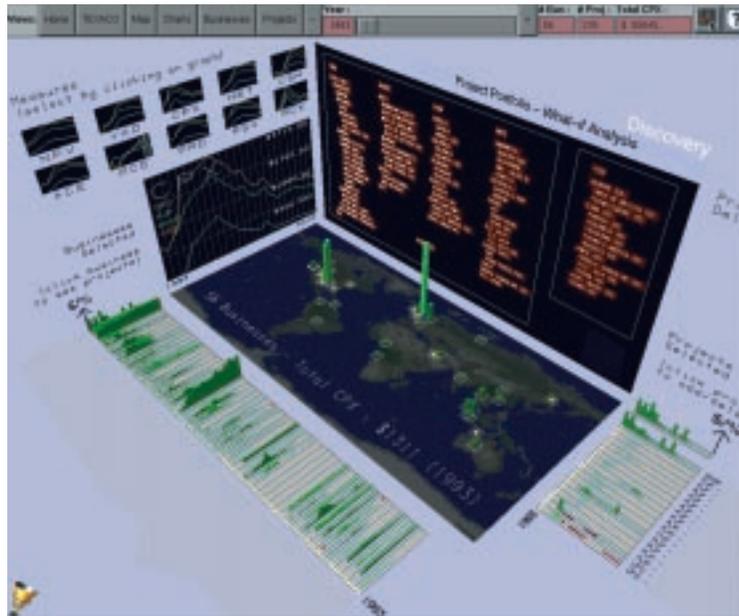


Image courtesy of Visible Decisions

ing company operating as many separate businesses. Each business is generally characterized by an initial intensive capital investment phase, followed by a revenue producing phase. Ten metrics are used to describe the risk and return of each business over its life span. The metrics also apply to the business as a whole.

With the right wall, users can select the whole business or a subsection for review and analysis. They can also select one of 10 performance metrics displayed on the left wall. That metric is then used in the detail chart on the left wall and also to show business performance by location (on the map in the center) and by time (along the left front). The right front of the screen is a working area for scenarios. Businesses can be added, removed, delayed, and accelerated.

This system lets managers evaluate and balance complex multidimensional factors. Risks and returns are clearly displayed for each business and for the corporation as a whole. Senior managers can immediately see the effect of questions like

4 Credit risk visualization.



Image courtesy of Visible Decisions

- “What if a business is delayed or stopped?”
- “What if a business has smaller revenue than expected?”
- “What are the pros and cons of supporting, or not supporting, a particular business?”

The application becomes a discussion vehicle as senior managers review and negotiate priorities. It

lets them plan more efficiently with the collective knowledge and insight of the management team.

Expiry (term to maturity, divided into buckets) is shown along the right axis and the underlying bond price on the left axis. This application displays each maturity bucket’s sensitivity to any underlying option-related pricing variable, such as strike price or short-term interest rate. Users can also interactively change the axes’ dimensions to show portfolio sensitivity measures such as delta, gamma, and vega. They can manipulate aggregate data from a wide variety of internal and external sources, while at the same time being able to drill down and examine transaction-level text-based details on any position. Many other visualization applications are possible in the capital markets.<sup>2</sup>

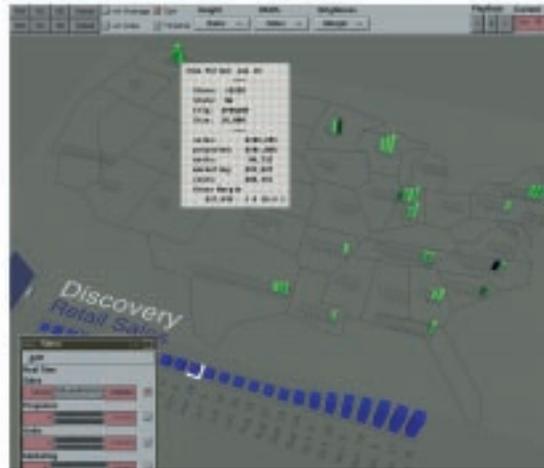
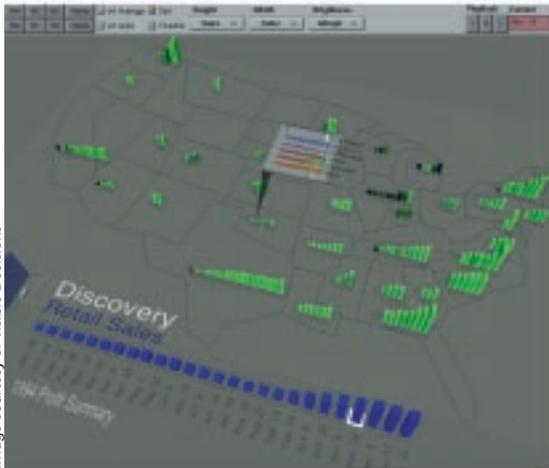
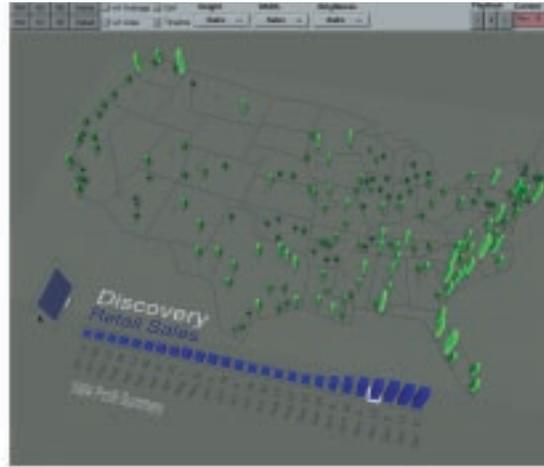
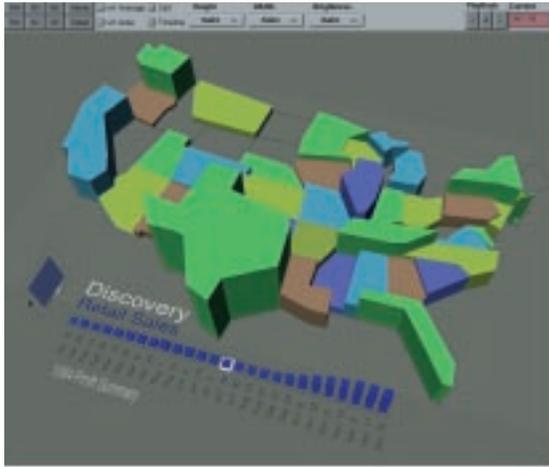
Management decision support

Figure 3 shows a senior management decision support application for a large international manufactur-

Credit scoring

In retail banking, credit policy managers assign a “score” to each possible answer on an application for a consumer loan. If they assign the scores properly, higher scores will correlate well with lower risk applicants. The scoring system relies on historical profiles of customer behavior. Different scoring systems are derived from and evaluated with observed customer characteristics such as demographics and product use. Developing accurate scorecards decreases credit risk (that is, loan defaults).

The visualization in Figure 4 looks at credit risk scoring parameters on hundreds of thousands of consumer loans. At the top, credit performance is shown by state and for the United States as a whole. Green represents



5 3D retail analysis tool showing aggregate regional and individual store performance.

Image courtesy of Visible Decisions

performing loans; yellow, delinquent loans; and red, loans in default. In the front left, the same loans are displayed by alternative credit score models plus several related dimensions that may or may not contribute to an indicative score. The scores and related dimensions are broken into buckets. Each bucket has an accompanying volume of loans and a performance profile. You can see which nontraditional dimensions contribute to an enhanced credit scoring policy.

This application provides graphical drill down. Users can select the loans in any bucket for detailed analysis. For example, in Figure 4 the loans in the highest income range bucket have been selected—and are displayed—in the center left, over the same dimensions. Another form of drill down is geographic. Any state can be selected, in this case Pennsylvania, and that state’s loans can then be analyzed over the same framework as shown on the front right. Drill down lets credit policy managers understand characteristics of similarly performing loans and compare measures in determining which is the most accurate for specific regions. The different organizing frameworks (geographic and parametric) provide insight into the variability of credit scores.

Visualization highlights patterns in credit performance, revealing surprising relationships. Existing credit policies can be compared with new policies, thereby improving the effectiveness of credit procedures.

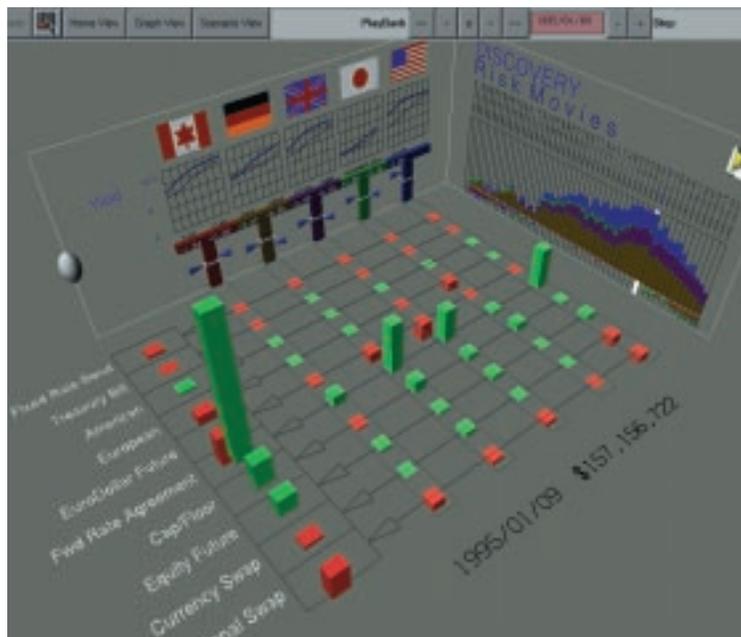
### Retail sales analysis

Figure 5 shows an interactive analysis tool used by product managers for a consumer product goods firm. These people review and analyze the performance of consumer products and the various factors affecting that performance (such as sales, projected sales, units, promotion, costs, and margin). Observations are made and conclusions reached about pricing, promotion, and distribution. This task requires users to review bimonthly performance data, over a year, for 175 stores.

Figure 5 shows aggregate regional performance as well as individual store performance. Performance over time can be “played back” in an animation. Product managers can sort stores within a region by performance and compare that performance to a benchmark. They can immediately see which stores and regions are above or below average. Pointing to any store provides precise text and numerical details.

For analysis purposes, users control a variable mapping of each store’s 3D graphical attributes (height, width, and brightness) and interactively assign these attributes to sales projections, actual sales, margin, costs, and so on. The analyst can then edit the mapping to “pull into focus” key business issues. For example, margin can be assigned to brightness. That way, all the bright spots can be seen, as well as the black holes (those stores with high sales but are losing money). Applying a filter on

## 6 A daily banking management report.



store size lets users focus on high-priority losses. For detailed analysis, graphical drill downs provide a picture of a year's worth of data for any particular store.

### Management reporting

Figure 6 shows a 3D reporting tool used by senior executives in a large bank. These people examine the bank's exposures in its global portfolio of financial instruments. Sensitivities (profit and loss) to changes in interest rates, currencies, and equity indices around the world must be reviewed.

Along the left is the global portfolio shown by asset classes. Along the right wall are 60 scenarios used to shock the portfolio. The scenarios are based on historical events like the 1987 stock market crash or the Japanese bubble. It is computationally intensive to calculate profits and losses on the thousands of complex instruments in the portfolio, and an overnight compute run must be done. Instead of reviewing a 60-page report every morning, the senior executives can use this 3D report.

Users select a scenario by pointing and clicking on the right wall. The profits and losses associated with that scenario appear in green and red, broken out by country. The rear wall displays a description of the market changes (interest rates, equity indices, and currencies) for that scenario. Users can play back, or animate, all 60 different market scenarios used to shock the global portfolio. The significance of these complex scenarios can be grasped in a few seconds.

Senior managers require simple, focused, and easy-to-use applications. For instance, predefined 3D navigation points-of-view are available in the menu bar as mini-reports. Clicking on one will move the view to the rear wall for a close look at what each scenario does to interest rates, currency rates, and equity indices.

It is interesting to note what happens in this report from a human perceptual and cognitive viewpoint. This

is a 10 by 6 profit and loss matrix displayed over 60 scenarios for a total of 3,600 profit and loss values, not to mention the description of market changes for each scenario. The layout can easily accommodate 100 or 200 scenarios. Compared to a traditional spreadsheet screen, which would show one scenario, this is a two orders of magnitude improvement in displaying information. The display lets the user, in just a few seconds, pick out the items of interest. Further, these items are presented in a context that supports informed evaluation.

### Conclusions

Rows and columns of numbers are appropriate for machine processing, but they don't draw upon human perceptual and cognitive strengths. With 3D and 4D graphical representations, people can see more information, more quickly, and with more comprehension. Information visualization has an important role within organizations. With significant investments made in computing infrastructures over the last decade, organizations have vast amounts of business data available to support decision making. Used effectively, information visualization can accelerate perception, provide insight and control, and harness this flood of valuable data to gain a competitive advantage in making business decisions. ■

### Acknowledgement

Thanks to the organizations that permitted discussion of their applications in this article.

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