Financevis.net : A Visual Survey of Financial Data Visualizations

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Abstract

We surveyed more than 50 papers that present visualizations of financial data, and made their references available on a website, http://financevis.net, that allows a user to browse thumbnails of the visualizations, and filter them by multiple criteria or perform a plain-text search. We discuss how we classified the visualizations, and outline ways to generate ideas for designing visualizations of financial data.

Index Terms: Computer Graphics [I.3.3]: Picture/Image Generation—Viewing algorithms

1 Introduction

The financial industry involves complex network flows of vast sums of money. In 2014, the world market capitalization reached a new record high of $62.4 trillion [12], and each day, $5.3 trillion are traded in foreign exchange markets [10]. Tasks related to finance can involve the monitoring of large numbers of frequent transactions and price fluctuations, and complex decision making that is sometimes done under tight time constraints. Visualization is one tool that can help with such tasks, and is already frequently used, such as in line graphs and candlestick charts. To help organize the field of visualization applied to financial data, we have identified over 50 papers, from 1992 onward, that present over 70 visualizations of financial data, and we have tagged these papers with metadata and made their references available on an interactive website (Figure 1). Our work is inspired by other recent surveys of domain-specific visualizations: `http://treevis.net` [13], `http://survey.timeviz.net` [1], `http://setviz.net` [2], and `http://dynamicgraphs.fbeck.com` [3].

2 Characterization of Papers

For each paper in our survey, we identified the one or more most interesting or novel visualizations in the paper, and catalogued these for our website. For example, if a paper presented a 3D variant of a treemap as well as a simple line graph, we included the 3D treemap in our survey, but not the simple line graph. Also, if a user interface with multiple views was presented, we only catalogued the most novel (sub)views within the interface, not the composite view.

In all of the papers surveyed, the data being visualized could be thought of as either multidimensional multivariate (mdmv) data [17], a tree, a network, or some combination of these. We first discuss the mdmv aspect, and then the tree and network aspects (which we refer to as Topology on our website).

In the visualization literature, the term mdmv refers to data that could be stored as tuples, where each tuple is a row in a table whose columns are either independent or dependent variables. Some authors [9] refer to these variables as dimensions and measures, respectively, and many authors distinguish between quantitative and

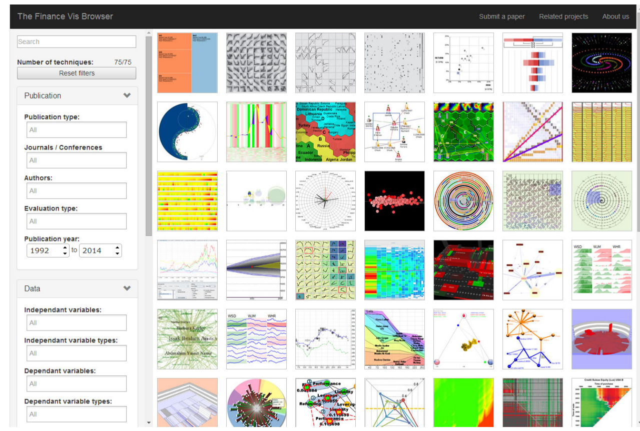

Figure 1: Screenshot of our website `http://financevis.net`

categorical variables, which we use as synonyms for continuous and discrete [9] respectively. Time is often thought of as a quantitative variable, however if Time is also an independent variable, it must be somehow discretized for storage in memory. For each visualization in our survey, we noted the number (0, 1, or Multiple) of independent and dependent variables, and also the types of variables (Categorical, Quantitative, and Time as a special 3rd case to avoid confusion). Our website allows the user to filter on these, and also filter on the type of chart (bar chart, line graph, etc.).

Turning to Topology, some of the visualizations we surveyed displayed a tree or network structure in the data, often in combination with mdmv aspects of the data. For example, a treemap can show hierarchical groupings of sectors that change over time, and a node-link diagram can show transactions in a network over time. Each visualization in the survey has a Topology of either Tree, Network, or None, which the user can filter on.

Separate from the number and type of variables in the data, and from the topology of the data, are the number of spatial variables in the visualization (catalogued as either 2D or 3D) and the use or non-use of animation in the visualization (catalogued as either Dynamic or Static, respectively). These are also available for filtering.

The tasks associated with each visualization were catalogued according to a taxonomy of financial functions and activities ('line of business' oriented). This taxonomy is based partly on [8], which, in turn, is based on the Basel Committee on Banking Supervision's mapping of core functions, and covers areas within retail banking, investment banking, asset management, and risk management. Most of the visualizations in our survey are oriented toward asset management, with a few oriented toward risk management (either financial stability monitoring, or fraud and market abuse detection and prevention). Several categories in our taxonomy are not yet populated, however they are available for use as the bibliography grows, and also suggest areas for future visualization work.

Finally, in cases where papers discussed interaction techniques, we catalogued these using the categories of interaction in [18], and also made these available for filtering the bibliography.

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3 How to Choose a Visualization Technique

Designers seeking ideas for visualizing their own data can use our website in several ways. If their data has tree or network aspects, they may filter for examples with such a topology. Designers can also filter by type or number of independent or dependent variables to see pertinent examples.

In the case of mdmv data, our survey encountered bar charts, line graphs, scatter plots, heat maps, and parallel coordinates. A few techniques were more exotic, such as the "Linked triangle chart" of [14], and the "Galaxy" and "Tai Chi" charts in [7]. Users may filter by visualization Type and/or Alignment (i.e., Perpendicular, Radial, Free, or Other), making it easy to quickly identify uses of, say, parallel coordinates, or the more unusual chart visualizations.

Tree structures can be visualized with node-link diagrams or with treemaps. However, in our survey, we saw trees visualized almost exclusively with treemaps. Networks can be visualized using node-link diagrams or adjacency matrices [5], however we saw node-link diagrams used almost exclusively, with one interesting exception appearing in [6] which used a sequence diagram to show transactions over time. The use of node-link diagrams for tree structures, and of adjacency matrices for networks, may be opportunities for financial visualization that have been underexplored.

Additional design ideas for visualizing financial data can be found in the existing surveys mentioned in the introduction, i.e., surveys of visualizations of trees, of dynamic graphs, and of time-varying data.

We have also identified a few general approaches for showing topology and simultaneously showing one or more variables (or time-varying data), some of which could yield novel results. First, consider showing topology with a node-link diagram, or treemap, or adjacency matrix. In any of these cases, dependent variables that are a function of the node can be shown as a color or glyph on each node. In the case of a treemap, the size of nodes can reflect another variable (however, this can make certain nodes very small, which may not be desirable). Variables that are a function of node and of time can also be shown as sparklines [15] on each node. Secondly, consider showing topology along one spatial axis (in the case of a network, this can be done with an arc diagram, and in the case of a tree, this can be done by laying out leaf nodes along an axis). It is then possible to show variables changing with time along a perpendicular axis. For example, [4] show both a tree structure and arc diagrams along one direction, and a time axis along the other direction, but not for financial data. Thirdly, it is possible to show topology within a plane, and time on a perpendicular axis, however we do not recommend such use of 3D—it is often better to have multiple 2D coordinated views to avoid occlusion and navigation problems [11].

4 Resources for Researchers

In addition to reviewing the literature covered by our website, readers interested in pursuing research in financial visualization can look at state-of-the-art industrial tools, including, but by no means limited to, Advanced GET by eSignal.com, MarketWatch.com's "Map of the Market" based on [16], and products by OmniTrader.com.

Several data sources are also available. Examples include Yahoo Finance, Google Finance and Oanda (Forex), which offer multiple free data feeds for asset management research. Note however that they may contain a higher number of errors or missing information and might not be the best sources for all projects. Commercial feeds, such as those provided by Bloomberg or Thomson Eikon, might be more accurate or complete. Researchers can also look to specialized distributors such as the Center for Research in Security Prices (CRSP), the Wharton Research Data Services (WRDS), the International Monetary Fund (IMF), the Bank for International Settlements or the World Bank for data.

5 Conclusion

Our website can be used to review previous literature, to answer questions about the literature (e.g., "How many papers involve Tree structures visualized in 3D?"), to find examples related to a given data set (based on the variables involved, and/or topology, and/or task), to identify the most unusual types of visualizations, or to find combinations that have not been attempted yet (such as Network structures visualized with an adjacency matrix or an arc diagram).

Authors are invited to submit new papers to be added to our bibliography by clicking on the "Submit a paper" option on our website and filling out the necessary information. We plan to eventually prepare a survey article about this work.

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