# A Systematic Literature Review on Visualization Techniques for Finance

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**Abstract**

This paper aims to explore the visualization techniques used in the financial field, in order to identify areas for further investigation and to define a state of the art on the matter.

## 1 Introduction

This paper reviews journals' and conferences' papers on visualization techniques for finance. In the last fifteen years, on-line trading has become the most used and important platform for trading on the stocks markets all over the world. As technology improves over the years, trading on-line platforms have become faster and more reliable. Nonetheless, the graphic instruments used by traders for buying and selling stocks on the markets have not changed much in the last years. For this reason, it's possible that newer instruments to visualize trading information and to operate on the markets could be researched, based on the latest innovations in data visualization. On this behalf, the main goal of this paper is to define which visualization techniques have been researched for financial visualization in order to direct further research.

## 2 Design

### 2.1 Goals

As the main goal of this review is to define references that could help the reader in directing further research, it is possible to distinguish many

different goals that define in more detail the state of the art. It is possible to identify at least the following major goals:

1. identify existing works;
2. identify the problems and thematics assessed;
3. identify the journal and/or institution that research on data visualization for finance;
4. identify which thematics have been more analysed and which were left over;
5. identify the evolution of the research in this field in the last years;
6. identify the most used techniques.

These goals define a specific scope for the research and could be translated in a set of research questions that should be assessed in the reading of each paper. Table 1 presents the list of questions and motivation proposed.

Table 1: Research questions.

| Question | Main Motivation |
|---|---|
| RQ1. Which and how many journals/conferences include papers on visualization techniques for finance? | Support researchers with a list of journals/conferences with potentially relevant papers. |
| RQ2. Who are the agencies or university that are interested in this field of research (e.g. Bloomberg)? | Identify major agencies investigating the same field. |
| RQ3. Which visualization tools were researched in the last years for this field? | Identify trends and possible shortcomings / opportunities for future research. |
| RQ4. What are the most investigated visualization problems? | Identify trends and possible shortcomings / opportunities for research topic focus. |

## 2.2 High Level Hypotheses

Data visualization has become an important field of research in the last years, due to the large amount of data (Big Data) collected by institutions

and private companies through the Internet. Big Data hold a great value that could be exploited only with the right instruments, that could properly filter and visualize the information in order to make them readable for the users. This kind of visualization techniques could provide important results on finance visualization and the combination of finance's instrument requirements and latest visualization techniques could lead to new interesting discoveries and researches.

## 2.3 Measures

The search for papers was performed on the following digital libraries/search engines: ACM, Google Scholar, IEEE, Springer, World Scientific.

At the beginning, a set of search strings was defined to perform the on-line research. This set was obtained with a trial and error approach, testing different combination of relevant words. Table 2 show the number of papers resulting from each search with the proposed search strings. In this step, the papers were selected manually reading titles and abstract of each paper. Column number two shows how many papers were selected from each search results with this analysis. At the end of this step, 68 papers were selected.

In the second step, all the selected papers were retrieved for a more detailed evaluation. In this phase only the introduction and conclusion were taken into account, to exclude papers with an unclear abstract and that could not be excluded in the first step. At the end of this step, 33 papers were selected.

In the third step, each paper was read with the intent of answering the research questions. If a paper failed to provide an answer at least to questions number three and four, it was then excluded from the review; actually 4 papers were excluded this way.

Moreover, the bibliography of each paper selected at step 1 was analysed looking for references to other relevant paper. As a result of this research, 17 papers were initially selected and 3 were excluded after the third selection step.

Table 2: Search strings, resulting papers and further selection.

| | | Analysis Steps | |
|---|---|---|---|
| Search Strings | Resulting Papers | 1st | 2nd |
| Finance Visualization | 14 | 4 | 4 |
| Financial Data Visualization | 48 | 25 | 11 |
| Financial Information Visualization | 4 | 2 | 2 |
| Financial Visualization | 53 | 12 | 5 |
| Market Data Visualization | 11 | 6 | 1 |
| Portfolio Visualization | 62 | 4 | 4 |
| Stock Data Visualization | 3 | 1 | 1 |
| Stock Portfolio Visualization | 31 | 8 | 2 |
| Stock Visualization | 27 | 6 | 3 |

# 3 Analysis method

## 3.1 Inclusion Criteria

As a result of the major goal defined in the previous section, the main criterion for including a journal paper in this review is that the paper should describe research on visualization techniques applied to finance. Papers regarding fraud detection systems, visualization of wire transactions, financial crime detection or bankruptcy analysis have not been included if a novel visualization technique is missing. Papers that solely discuss existing papers and/or methodology have been omitted. Papers that provided a review of existing techniques have been taken in great account for two reasons: firstly, to verify that at least all the techniques discussed in those papers and corresponding to the chosen criteria where retrieved through the methodology hereby proposed; secondly, to find out if existing or newer paper, missing in those papers but relevant to the proposed goals, are included in this review, thus confirming the relevance of this work. There were samples of papers describing the same technique in more than one paper, with slight differences or some minor improvements. As this occurred only in a small amount of cases, these papers were not excluded by the current review. However, it should be observed that if the goal of the review is to evaluate the relevance of a technique or methodology, these duplicate papers should be properly considered.

## 3.2 Classification

For the purpose of addressing the research questions, each paper that satisfied the inclusion criteria was classified according to the properties listed in Table 3. The categories are based on the two most important quality of each visualization technique: the graphic tool involved and the purpose of the technique. The aim of this classification is to answer the research questions RQ3 and RQ4. The categories proposed are non exclusive: a paper may focus on more than one finance visualization tool and could provide an answer to different visualization tasks.

Table 3: Classification of papers.

| Property | Categories |
|---|---|
| Tool Involved | Time Line Chart, Diagram, Tree Map, User Interface, Map, Matrix, News |
| Problem addressed | Series Analysis, Pattern Similarity, Pattern Discovery, Events Correlation, Market Analysis |

# 4 Results

## 4.1 RQ1. Relevant Journals and Conferences

Papers on visualization techniques for finance were found in as many as 31 journals and/or conferences. Actually this is far beyond expectation, but it is possible to identify two important papers/conferences with at least 4 papers each: IEEE Information Visualization Conference and IEEE Transactions on Visualization and Computer Graphics. This two entries represents more than 20% of the selected papers ( 10 out of 46). The list of journals and conferences is reported in Appendix A.

## 4.2 RQ2. Relevant Agencies

The review outline 35 university/agencies investigating visualization techniques for finance, with the following geographical distribution: fourteen entities from Europe, fifteen from North America, 4 from Asia and 2 from Oceania.

The most important university outlined with this analysis is the University of Konstanz, located in Germany, with 7 relevant papers, corresponding to 15% of the selected papers.

## 4.3 RQ3. Relevant Visualization Tools

Through the classification proposed earlier in this paper, it was possible to identify the visualization tools generally addressed. Table 4 highlight how many papers address each visualization tools.

It is evident that the majority of the papers focuses on the time line chart and the tree map. Moreover, the majority of the papers proposes improvements or evolution for existing finance visualization tools. These results show that only few papers investigate innovative visualization tools. Most of the time, the authors propose an evolution of an existing instruments or a new functionality to make better use of an available tool. Therefore, a possible focus for future research is proposing existing visualization tools not yet used in the finance domain, or investigating new visualization solutions based on the state of the art of data visualization.

Table 4: Classification of papers.

| Tools | Occurrences | Percentage |
|---|---|---|
| Diagram | 3 | 6.5% |
| Map | 2 | 4.35% |
| Matrix | 2 | 4.35% |
| News | 3 | 6.5% |
| Time Line Chart | 16 | 34.8% |
| TreeMap | 10 | 21.7% |
| User Interface | 2 | 4.35% |

## 4.4 RQ4. Relevant Problems

Table 5 shows the distribution of problems addressed in the selected papers. Most of the papers focuses on Series and Market Analysis. This is in accordance with the need of the final user to better understand both the market trend as a whole and the trend of the specific stocks he chooses to trade on. Some papers focus on the problem of detecting patterns, in

order to offer a better insight on the possible outcomes of the market. However, none of the paper selected through the review propose any innovation on the instruments used to actually perform the trading, such as the flashbook or the multibook. Likewise, none of the paper investigates instruments specifically developed to choose the stocks to trade on, such as the stock picker. Further research could focus on these aspects that are missing in the current review.

Table 5: Problems addressed in the papers.

| Problem | Occurrences | Percentage |
|---|---|---|
| Events Correlation | 3 | 6.5% |
| Market Analysis | 18 | 39% |
| Pattern Discovery | 4 | 8.7% |
| Pattern Similarity | 3 | 6.5% |
| Series Analysis | 17 | 37% |

# 5 Conclusions

The research successfully answers the questions posed at the beginning of the review process. Moreover, it outlines interesting opportunities for future research.

The main limitation of the study is represented by the small amount of research engines and digital libraries used to select the papers (only five). Moreover, finance is a huge field to investigate and it's possible that not all the existing papers have been discovered with the chosen search strings. For this reason, if an author would like to investigate one of the outlined research opportunities, it is suggested to perform a more specific review based on the focus of his research.

# Appendix A List of included papers

Savikhin, A., Maciejewski, R., & Ebert, D. S. (2008, October). Applied visual analytics for economic decision-making. In Visual Analytics Science and Technology, 2008. VAST'08. IEEE Symposium on (pp. 107-114). IEEE.

Schaefer, M., Wanner, F., Kahl, R., Zhang, L., Schreck, T., & Keim, D. (2011). A Novel Explorative Visualization Tool for Financial Time Series Data Analysis. Bibliothek der Universitt Konstanz.

Lai, S., & Fu, H. C. (2010). A polygon description based similarity measurement of stock market behavior. Expert Systems with Applications, 37(2), 1113-1123.

Ziegler, H., Schreck, T., Nietzschmann, T., Schelwies, N., Schneidewind, J., & Keim, D. A. (2006). A Spectral Visualization System for Analyzing Financial Time Series Data.

Huang, M. L., Liang, J., & Nguyen, Q. V. (2009, July). A visualization approach for frauds detection in financial market. In Information Visualisation, 2009 13th International Conference (pp. 197-202). IEEE.

Schwabish, J. A. (2014). An Economist's Guide to Visualizing Data. The Journal of Economic Perspectives, 28(1), 209-233.

Aigner, W., Kainz, C., Ma, R., & Miksch, S. (2011, March). Bertin was Right: An Empirical Evaluation of Indexing to Compare Multivariate TimeSeries Data Using Line Plots. In Computer Graphics Forum (Vol. 30, No. 1, pp. 215-228). Blackwell Publishing Ltd.

Onak, K., & Sidiropoulos, A. (2008, June). Circular partitions with applications to visualization and embeddings. In Proceedings of the twenty-fourth annual symposium on Computational geometry (pp. 28-37). ACM.

Ertl, T., Joy, K., & Santos, B. Combining Extended Table Lens and Treemap Techniques for Visualizing Tabular Data.

Hullman, J., Diakopoulos, N., & Adar, E. (2013, April). Contextifier: Automatic generation of annotated stock visualizations. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 2707-2716). ACM.

De Berg, M., Speckmann, B., & van der Weele, V. Convex Treemaps with Bounded Aspect Ratio. EuroCG,(Mar. 2011), 71-74.

Pandya, A., Mulye, A., & Teoh, S. T. (2011, January). Enhancing online timeline visualizations with events and images. In IS&T/SPIE Electronic Imaging (pp. 78680W-78680W). International Society for Optics and Photonics.

Dumas, M., McGuffin, M. J., & Lemieux, V. L. Financevis. net: A Visual Survey of Financial Data Visualizations.

Sorenson, E., & Brath, R. (2013, July). Financial Visualization Case Study: Correlating Financial Timeseries and Discrete Events to Support Investment Decisions. In Information Visualisation (IV), 2013 17th International Conference(pp. 232-238). IEEE.

Rudolph, S., Savikhin, A., & Ebert, D. S. (2009, October). FinVis: Applied visual analytics for personal financial planning. In Visual Analytics Science and Technology, 2009. VAST 2009. IEEE Symposium on (pp. 195-202). IEEE.

Hao, J., Zhang, K., Gabrysch, C. A., & Zhu, Q. (2009). Managing Hierarchical Information on Small Screens. In Advances in Data and Web Management (pp. 429-441). Springer Berlin Heidelberg.

Laine-Hernandez, M., & Srkk, N. Market Data VisualizationConcepts, Techniques and Tools

Pryke, M. (2010). Money's eyes: the visual preparation of financial markets.Economy and Society, 39(4), 427-459.

Marghescu, D. (2007). Multi-dimensional Data Visualization Techniques for Exploring Financial Performance Data. AMCIS 2007 Proceedings, 509.

Tue Dao, H., Bazinet, A., Berthier, R., & Shneiderman, B. NASDAQ Velocity and Forces: An Interactive Visualization of Activity and Change.

Ziegler, H., Keim, D. A., & Nietzschmann, T. (2007). Relevance driven visualization of financial performance measures.

Fu, T. C., Chung, F. L., Luk, R., & Ng, C. M. (2008). Representing financial time series based on data point importance. Engineering Applications of Artificial Intelligence, 21(2), 277-300.

Heer, J., Kong, N., & Agrawala, M. (2009, April). Sizing the horizon: the effects of chart size and layering on the graphical perception of time series visualizations. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1303-1312). ACM.

Tanahashi, Y., & Ma, K. L. (2015, April). Stock Lamp: An Engagement-Versatile Visualization Design. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (pp. 595-604). ACM.

Fu, T. C., Chung, F. L., Kwok, K. Y., & Ng, C. M. (2008). Stock time series visualization based on data point importance. Engineering Applications of Artificial Intelligence, 21(8), 1217-1232.

Sanz Merino, C., Sips, M., Keim, D. A., Panse, C., & Spence, R. (2006). Task-At-Hand Interface for Change Detection in Stock Market Data.

Savikhin, A. C. (2013). The Application of Visual Analytics to Financial Decision-Making and Risk Management: Notes from Behavioural Economics. In Financial Analysis and Risk Management (pp. 99-114). Springer Berlin Heidelberg.

Huang, M. L., Huang, T. H., & Zhang, J. (2009, July). Treemapbar: Visualizing additional dimensions of data in bar chart. In Information Visualisation, 2009 13th International Conference (pp. 98-103). IEEE.

de Berg, M., Speckmann, B., & van der Weele, V. (2011, December). Treemaps with Bounded Aspect Ratio. In ISAAC (pp. 260-270).

Alsakran, J., Zhao, Y., & Zhao, X. (2010, January). Tile-based parallel coordinates and its application in financial visualization. In IS&T/SPIE Electronic Imaging (pp. 753003-753003). International Society for Optics and Photonics.

Schreck, T., Tekuov, T., Kohlhammer, J., & Fellner, D. (2007). Trajectory-based visual analysis of large financial time series data. ACM SIGKDD Explorations Newsletter, 9(2), 30-37.

Marghescu, D. (2007). User evaluation of multidimensional data visualization techniques for financial benchmarking. In Proceedings of the European Conference on Information Management and Evaluation (p. 341). Academic Conferences Limited.

Hong, C. F., Chiu, T. F., Chiu, Y. T., & Lin, M. H. (2007). Using conceptual scenario diagrams and integrated scenario map to detect the financial trend. InNew Trends in Applied Artificial Intelligence (pp. 886-895). Springer Berlin Heidelberg.

Shen, X., & Eades, P. (2005, January). Using MoneyColor to represent financial data. In proceedings of the 2005 Asia-Pacific symposium on Information visualisation-Volume 45 (pp. 125-129). Australian Computer Society, Inc..

Dumas, M., McGuffin, M., & Chass, P. VectorLens: Angular Selection of Curves within 2D Dense Visualizations.

Ziegler, H., Nietzschmann, T., & Keim, D. (2007, July). Visual exploration and discovery of atypical behavior in financial time series data using two-dimensional colormaps. In Information Visualization, 2007. IV'07. 11th International Conference (pp. 308-315). IEEE.

Archambault, D., Munzner, T., & Auber, D. (2006). Visual exploration of complex time-varying graphs. Visualization and Computer Graphics, IEEE Transactions on, 12(5), 805-812.

Chiu, T. F., Hong, C. F., & Chiu, Y. T. (2008). Visualization of financial trends using chance discovery methods. In New Frontiers in Applied Artificial Intelligence (pp. 708-717). Springer Berlin Heidelberg.

Marshall, B., Mortenson, K., & Bourne, A. (2010). Visualizing basic accounting flows: does XBRL+ model+ animation= understanding?.

Vliegen, R., van Wijk, J. J., & Van der Linden, E. J. (2006). Visualizing business data with generalized treemaps. Visualization and Computer Graphics, IEEE Transactions on, 12(5), 789-796.

Chiu, T. F., Hong, C. F., & Chiu, Y. T. (2009, April). Visualizing the financial situations and trends via chance discovery. In Intelligent Information and Database Systems, 2009. ACIIDS 2009. First Asian Conference on (pp. 92-97). IEEE.

Alsakran, J., Zhao, Y., & Zhao, X. (2009, July). Visual analysis of mutual fund performance. In Information Visualisation, 2009 13th International Conference (pp. 252-259). IEEE.

Ziegler, H., Nietzschmann, T., & Keim, D. (2008, July). Visual analytics on the financial market: Pixel-based analysis and comparison of long-term investments. In Information Visualisation, 2008. IV'08. 12th International Conference (pp. 287-295). IEEE.

Ziegler, H., Jenny, M., Gruse, T., & Keim, D. (2010, October). Visual market sector analysis for financial time series data. In Visual Analytics Science and Technology (VAST), 2010 IEEE Symposium on (pp. 83-90). IEEE.

Balzer, M., Deussen, O., & Lewerentz, C. (2005, May). Voronoi treemaps for the visualization of software metrics. In Proceedings of the 2005 ACM symposium on Software visualization (pp. 165-172). ACM.

Jiang, T. T., Wang, Q. G., Zhang, H. K., Xiao, W. D., Zhang, C., & Ge, B. (2014, September). ZFDV: Zoom Financial Data Visualization in the Era of Big Data. In Advanced Materials Research (Vol. 989, pp. 2457-2461).

# Appendix B Classification descriptions

Diagram: a graphical representation of data that help the user analysing the market.

Map: a map representation of data to understand the trend of the market.

News: a tool that correlate events occurring all over the world and the trend of stocks and markets.

Time Line Chart: a line chart displaying the temporal trend of a stock.

TreeMap: a specific finance visualization tools used to outline stocks', sectors', and market's trend.

User Interface: a graphical representation and/or arrangement of financial visualization tools that should facilitate the user understanding the data.

Events Correlation: correlation between events occurring all over the world and the trend of stocks and markets to predict their trends.

Market Analysis: analysis of the market to predict its trend.

Pattern Discovery: analysis of the time line chart of a stock to identify a pattern and predict the trends of the specific stock in the future

Pattern Similarity: analysis of the time line chart to identify a known pattern in order to predict the stock trend or to outline a correlation between different stock with the same pattern.

Series Analysis: analysis of a single stock to predict its trend.

# Appendix C List of Journals and Conferences

IEEE, Visual Analytics Science and Technology

UKVAC Workshop on Visual Analytics

IEEE, Congress on Evolutionary Computation

IEEE, International Conference on Information Visualisation

Journal of Economic Perspectives

Computer Graphics Forum

ACM, Symposium on Computational geometry

ACM, SIGCHI Conference on Human Factors in Computing Systems

EuroCG

International Society for Optics and Photonics, IS&T/SPIE Electronic Imaging

Springer, Advances in Data and Web Management

Next Media research programme (2010-2013)

Taylor & Francis, Economy and Society

EUROVIS

Engineering Applications of Artificial Intelligence

ACM, Conference on Human Factors in Computing Systems

Springer, Financial Analysis and Risk Management

ISAAC

International Society for Optics and Photonics, IS&T/SPIE Electronic Imaging

ACM, SIGKDD Explorations Newsletter

Proceedings of the European Conference on Information Management and Evaluation

New trends in applied artificial intelligence

Asia-Pacific symposium on Information visualisation

IEEE, Transactions on Visualization and Computer Graphics

Springer, New Frontiers in Applied Artificial Intelligence

The International Journal of Digital Accounting Research

IEEE, First Asian Conference on Intelligent Information and Database Systems

IEEE, Visual Analytics Science and Technology

ACM, symposium on Software visualization

Trans Tech Publications Inc., Advanced Materials Research