Designing Interactive Visualization Methods for Comparing Multivariate Stock Market Data over Time

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Rui Ma
Matrikelnummer 0208139

an der
Fakultät für Informatik der Technischen Universität Wien

Betreuung:
Betreuerin: Univ.-Prof. Mag. Dr. Silvia Miksch
Mitwirkung: Dipl.-Ing. Dr. Wolfgang Aigner

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Abstract

This master thesis explores key requirements for the design of interactive visualization methods for comparing multivariate stock market data.

Superimposed line charts are commonly used for comparison of stocks in modern stock market visualizations. A problem is appearing, when the difference(s) between the price ranges is (are) large. These differences result in distortion and a display of flattened curves, which make comparisons very difficult. Another problem is that stocks and stock indices do not have the same unit. In this case juxtaposed line charts are often used to compare the data. However the data does not share the same y-axis. Other than that, superimposed charts with multiple y-axes might be used. Relationships are then depending on the ranges of the involved y-axes, which makes the visual appearance often completely arbitrary. The third problem is that stock market visualizations often use linear scales. Unfortunately this scale can lead to false conclusion of comparisons with percent estimations.

A user & task analysis with six domain experts was conducted to find common user tasks and requirements for the design of a stock market visualization prototype. The main subjects of the analysis are user tasks, visualizations & interactions and related economic data.

After the development of the prototype, a user study with five domain experts was conducted. The purpose of this study is to gain feedback about the usability and the applicability of the prototype from expert users.

All participants of the user study have agreed that a comparison of multiple stocks by superimposition is more effective than by juxtaposition. The domain experts also think that indexed line charts are an excellent method to compare percent changes. The indexing method can display various stock market data with different units using only one chart. This makes relative comparison tasks of stock market data very effective. The ability to select the indexing point freely is considered by all participants as an important and useful function.

According to the user study, the logarithmic scale is more useful than the linear scale for comparisons of stock market data. Also it is best to compare a group of stocks or a stock market index with economic data like GDP or interest rates. This removes any individual effects of a particular stock.

Kurzfassung

Diese Diplomarbeit erforscht die wesentlichen Anforderungen für das Design von interaktiven Darstellungsmethoden für den Vergleich von multivariaten Börsendaten.

In modernen Darstellungen von Aktienmarktdaten werden häufig übereinanderliegende Liniendiagramme für den Vergleich der Aktienpreise verwendet. Ein Problem entsteht, wenn die Differenz(en) zwischen den Preisen zu groß ist (sind). Diese Unterschiede führen zu Verzerrungen bzw. der Darstellung von stark abgeflachten Kurven, was Vergleiche sehr erschwert. Ein weiteres Problem besteht darin, dass Aktien und Aktienindizes nicht die gleiche Einheit haben. In dem Fall werden oft nebeneinanderliegende Liniendiagramme genutzt, um die Daten zu vergleichen. Die Daten verwenden jedoch nicht die gleiche y-Achse. Die Vergleiche sind daher abhängig von der Auswahl der y-Achse, was die Vergleiche völlig willkürlich macht. Das dritte Problem ist, dass Darstellungen von Aktienmarktdaten oft eine lineare Skalierung verwenden. Diese Skalierung kann aber auch zu falschen Schlüssen bei Vergleichen mit prozentuellen Schätzungen führen.

Eine User & Task-Analyse mit sechs Fachexperten wurde durchgeführt, um übliche Aufgaben und Anforderungen für das Design eines Prototyps zur Darstellung von Börsendaten zu finden. Die wichtigsten Themen der Analyse sind die Identifizierung von Aufgaben, gebräuchliche Visualisierungen und deren Interaktionen und weitere wirtschaftlichen Daten, die mit Aktienmarktdaten verbunden sind.

Nach der Entwicklung des Prototyps wurde eine Benutzerstudie mit fünf Fachexperten durchgeführt. Ein wichtiges Ziel dieser Studie ist, Feedback von erfahrenen Nutzern über die Usability und die Anwendbarkeit des Prototyps zu erhalten.

Alle Teilnehmer der Benutzerstudie haben sich darauf geeinigt, dass ein Vergleich von mehreren Aktien mittels der Darstellung durch Übereinanderlegung wirksamer ist als mittels einer Darstellung durch Nebeneinanderlegung. Die Fachexperten sind der Meinung, dass indizierte Liniendiagramme eine hervorragende Darstellung sei, um prozentuelle Veränderungen zu vergleichen. Die Indizierungsmethode kann verschiedene Aktienmarktdaten mit unterschiedlichen Einheiten auf einem einzigen Chart darstellen. Dies ermöglicht relative Vergleiche von Börsendaten sehr effektiv durchzuführen. Die Möglichkeit, den Basispunkt der Indizierung frei zu wählen, ist von allen Teilnehmern als eine wichtige und nützliche Funktion empfunden worden.

Der Benutzerstudie zufolge, ist eine logarithmische Skalierung viel nützlicher als eine lineare Skalierung für den Zweck eines Vergleiches von Börsendaten. Wirtschaftlichen Daten wie BIP oder Zinsen sollten am besten mit einer Gruppe von Aktien oder einen Aktienindex verglichen werden. Dadurch werden sämtliche individuelle Effekte einer bestimmten Aktie entfernt.

Contents

1 Introduction

"Look at market fluctuations as your friend rather than your enemy; profit from folly rather than participate in it." (Warren Buffett)

Stock prices are changing continuously as a function of supply and demand of real-time trading.

Every investor has different methods to decide whether to buy, hold or sell shares. Some investors rely on opinions of experts or on news reports. Other investors may check periodically current stock prices. Other factors can be stock market information such as the historical price and volume values, company information, correlations between stocks and national or international economic data and events.

The decision process depends strongly on individual preferences of the investor. But having access to valuable and meaningful information is a key premise of intelligent decisions.

Stock prices are often represented by numbers. Development of stock prices is usually represented by a line chart, which encodes the values of historic stock prices. Statistical processes are often used to analyze trends within the time series data.

1.1 Motivation

"The stock market is one important domain where complex data arise. There are thousands of companies in the market, and the performance of each one is typically measured by chart diagrams showing price fluctuation over time. Analyzing and understanding these charts by, i.e., tables of numbers are difficult if generally possible." [Šimunić, 2003]

As the previous citation states, the task of comparing stocks is not as easy as it may seem. Stocks generate a massive amount of data each day. Each stock trade influences the price of a share. Most people are familiar with one price per day. But actually this is only the price of the last trade. Besides the closing price are three other stock prices commonly used in stock market analysis. Opening, highest and lowest price are able to deliver additional information for the investor.

However, numerical tables are limited in the ability to display the data. Paradoxically the values are very precise, though numbers alone cannot really show relationships and the development of the values.

One way to reduce the complexity of the previous mentioned data tables is to use statistical formulas which can describe important characteristics of the data. For example, the trend of a stock, or generally speaking of a time series, can be inferred by a stochastic model like the moving average. The calculation of a correlation between two time series can help to identify patterns or dependencies between time series. Most finance professionals use such and more sophisticated mathematical respectively the statistical methods to compare stocks. Those comparisons influence further decisions in trading.

Another method to compare stocks is done by looking at visualizations of the data. Though this method is less precise than a numerical table it has some strong advantages. Visualizations in general offer a much faster recognition of the trends and patterns of the represented data. The human perception of graphical shapes is much better than of a table of numbers.

It is not surprising, that amateur traders often use visualizations like line charts for technical analysis of the data. But visualizations offer more advantages. The communication about the data is easier. Also the density of information is greater resulting in less needed space.

Stock market sections in news papers often print stock data in tabular format. The closing price and a percentile change are most common. Sometimes the data is accompanied by line charts, which indicate the prices of the last month or two weeks.

The space requirements of a graph can be fixed to a specific or available size. Numerical tables are more dependent on the count of the data items. Also visualizations transform data and relations of data into shapes, which leads to an easier and faster understanding of the underlying data for humans. Furthermore visualizations can show us relationships between data series very well. Patterns and fluctuations of time series are easily spotted with graphical representations.

Consequently, visualizations should be quite capable instruments for comparison tasks of multivariate data.

1.2 Problem Description

The comparison of several stocks against each other is an important task in the financial analysis. As previously mentioned a comparison of large sets of numerical values is for most humans more difficult than comparing simple shapes. This section will show the three main problems of visual comparisons.

 "The usual visualization of a stock chart looks like a 2-dimensional graph, where the x-axis represents time and the y-axis the stock price. This visualization implements insight into price fluctuation of one stock.[…] However, if we are interested to get insight into several stock charts in a way that we can compare charts, this technique will hardly do." [Šimunić, 2003]

The following text will introduce three central problems of visual comparisons. The first problem occurs only in juxtaposed graphs. The second and third problems happen only in superimposed graphs.

Most stock market visualizations display only one stock or stock index. Comparisons are done by using multiple graphs where each graph has a different axis price range. This reduces greatly the accuracy of visual comparison task results.

The second problem occurs while performing visual comparisons in superimposed graphs. Usually the price range of the y-axis is automatically adjusted to fit all prices. For different prices of the displayed time series this leads to a wide total price range. As a consequence smaller changes of the price are then drawn as a flat line.

The Figure 1 demonstrates an example chart of this problem. The line chart shows two stocks in green and in blue color represent the closing prices of a six month period. While each segment between two price values of the green colored line is clearly visible, the blue colored stock is drawn as a line because of the relative small changes compared to the wide total price range.
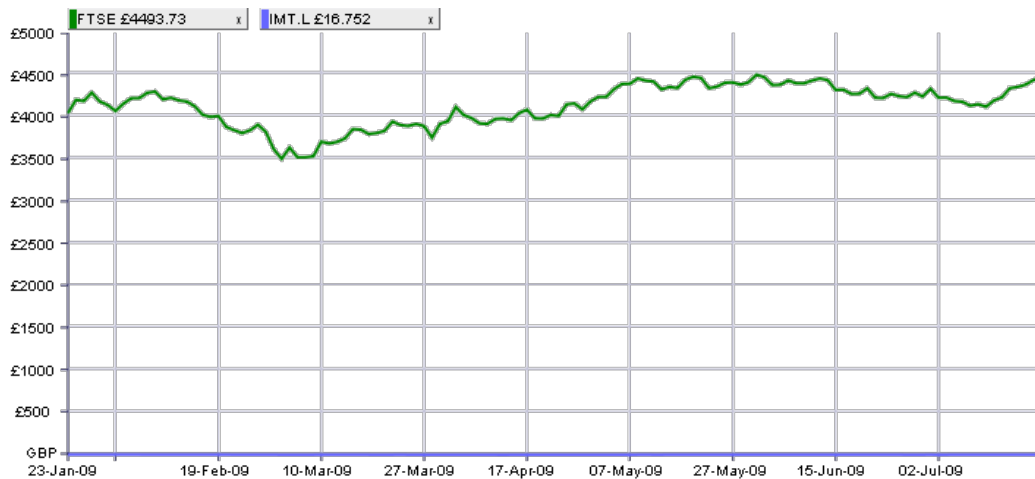
Figure 1: Two stocks with too big price difference [iGrapher, 2009]

The price of the green colored stock FTSE ranges from £ 3512 to £ 4506, while the prices of the blue colored stock IMT.L ranges from £ 14.3 to £ 18.99. The difference between the ranges is too big. This has a great impact on the visualization, because the changes of the blue colored stock are practically invisible to the viewer.

Another source for problems when visually comparing stocks is the default usage of a linear axis scale. The linear scale is well suited for displaying and comparing absolute values. But it is not adequate for tasks which base on percentage changes.

The Figure 2 shows three exemplary stocks A, B and C from 1990 to 2000. The price of stock A changed from 3.5 to 6.5. This is an 85.7% increase of the price. The price of stock B increased from 15.7 to 24 which results in a 52.9% increase. Stock C has an increase of 122%.

Stock C has made the biggest increase which is also clearly visible in the chart. However it is not visible that stock A has a 30% greater increase than stock B. The gradient of stock B is a little bit steeper which can lead to false conclusions about the changes. The value of the start point of the increase is crucial for the drawn gradient for linear scaled axis.

Consequently visual comparisons of percentage changes are not possible with commonly used linear scaled axes.

Figure 2: Percent changes and linear scale

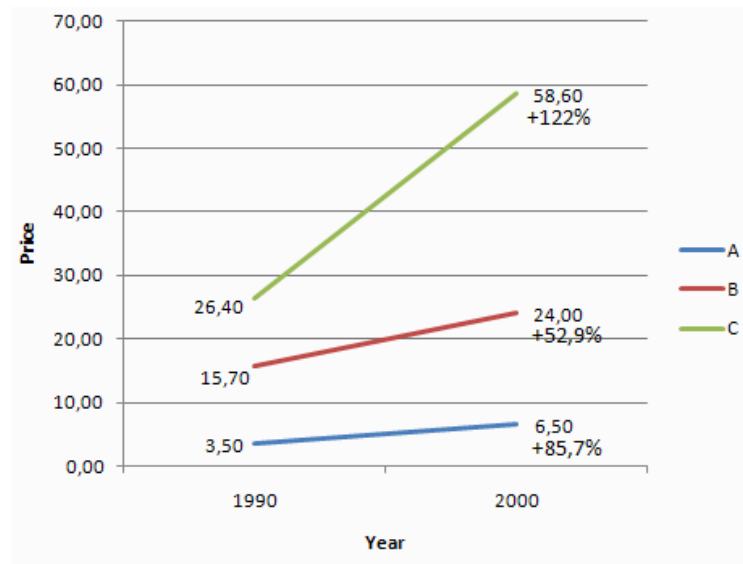The stock price is to a great extent dependent on supply and demand. However demand and supply may be influenced by other economic data. For instance the setting of the interest rate is a popular monetary tool of national banks to increase or decrease stock market investments. Other economic data may influence a certain stock market segment. For example, the stock price of a large transport company or airline is more influenced by current oil prices than the average IT company.

However such generalizations of dependencies are almost impossible. Economic data series may affect stock prices but there is most certainly a varying delay between them, so correlations are hard to analyze and causal relations are in general unpredictable. The effects may not be constant and therefore change from time to time. Individual events may be affected by multiple causal effects which may interfere each other. Effects may add or subtract each other resulting in an unpredictable total effect outcome.

The subject of the present master thesis is not only the analysis of dependencies or correlations. The aim is to develop an interactive visualization which helps to find interesting relations within several stock market data and also to identify relations to general economic data.

1.3 Research Questions

The research questions can be divided into the area of data-related questions and task-related questions. These questions will hopefully provide valuable information for the design of a software prototype for visualization of multivariate stock market data. They will also provide a list of important tasks which will be needed for the evaluation of the visualization prototype.

1.3.1 Data-related questions

The most popular visualization of stock market data is the line chart. This chart displays only closing prices of the stock. HLC (Highest, Lowest & Closing prices) and OHLC (Opening, Highest, Lowest & Closing prices) graphs display additional stock market data such as (opening,) highest, opening and closing prices. The extra information of the opening price, highest price and lowest price can help to understand the market situation better. The trading volume is also sometimes displayed at the bottom of the chart.

How useful is the common information of stock market data?

This goal of this question is to determine the usefulness of the closing price and additional data like opening, highest and lowest price. The usefulness of the trading volume is also of importance.

What information do different types of investment strategies (short, medium, long investment periods) need?

This question investigates which type of investor requires intra-day information such as opening and current highest, lowest and latest prices. The importance of the trading volume for the different type of investor will also be part of the research.

What other financial data would be useful for analyzing stocks?

Stock prices depend on supply and demand of the stock shares. This question wants to find possible economic data that may be related to the development of stock prices. With the support of domain experts economic data will be identified. Example economic indicators could be interest rates, inflation rates and GDP.

How useful is the additional information from these other indicators?

Can economic data be used to find patterns or trends for stock prices? Another implication of this research question is if such relations can be generalized.

1.3.2 Task-related questions

The following research questions are related to common and important tasks for finance experts. With these questions a collection of important tasks will be created. This collection will be of further help to create requirements and evaluation tasks.

What tasks are important for domain experts?

An identification of the most common tasks will be performed. We want to find the main tasks which are used for graphical analysis of stock market data. The list of important tasks will aid us in understanding the needs of the users. We will acquire the list by interviewing domain experts and by analyzing existing software.

How to improve existing tasks?

Qualitative interviews of domain experts will help to find problems of existing tasks and may also provide solutions for improving existing tasks.

1.4 Overview

The following text describes the structure of this thesis. In chapter 2 the stock market charts visualization used for technical analysis and the comparison methods of stocks are described. In chapter 3 common web applications for stock market visualization are introduced. In chapter 4 the user & task analysis for stock market visualizations is given, which is based on six interviews with domain experts and on a general task taxonomy for temporal data. In chapter 5 the requirements, design, architecture and important interactions of the prototype are presented. In chapter 6 the user study which evaluates the applicability and usability of the prototype is summarized. At last, the conclusion and possible future works are presented in chapter 7.

2 State of the Art: Stock Market Visualizations

The importance of stock markets as an investment opportunity has increased in the last decades constantly. Stock investors come from various areas such as pension funds, banks, hedge funds, private investors, etc.

While many professionals use mathematical models to compare and predict stock price movements, most private traders rely on stock market charts. This may be because visualizations are easier to understand and do not require the theoretical and mathematical knowledge.

Since many years, newspapers are using stock charts to visualize current trends in addition to stock prices in tabular format. Many companies provide software and web applications for stock market visualizations as the demand for such applications is increasing.

The first section 2.1 will briefly explain the two most used analytical models for stock markets. The second section 2.2 introduces the four most commonly used stock visualizations. They are line chart, OHLC (Opening, Highest, Lowest & Closing prices) chart, candlestick chart and the point & figure chart. The following section 2.3 describes the effects, advantages and disadvantages of linear and logarithmic scales. This is especially important for comparisons of percent changes between multiple stocks. The trading volume is a key indicator for many investors. The most relevant visualizations for the display of volume information will be explained in section 2.4.

Multiple stocks are usually compared by juxtaposition. Each stock is separately drawn on an own chart. The charts are then placed on top of each other. Another method would be to overlay the stocks into a single chart. This comparison method is called superimposition.

More advanced comparison methods are realized through the usage of specialized visualizations. sparklines, horizon graphs, the indexing method and treemaps will be described in section 2.5.

2.1 Analytical models

The term stock price is commonly associated with the closing price. The closing price refers to the stock price of the last trade of a day. Three other stock prices are additionally used. The opening price refers to the stock price of the first trade of the day. Highest and lowest stock prices refer to the maximum and minimum prices of the day.

Stock trading involves many opportunities and many risks as well. Traders have developed investment strategies to minimize the risks. The trading strategies influence investment decisions such as when to buy and when to sell stocks.

Finance literature distinguishes between two analytical models for stock analysis. Both determine when the investor should buy or sell stocks. The first method is the technical analysis and the second method is the fundamental analysis. More information about both methodologies is obtainable in [Investopedia, 2009].

The technical analysis and the fundamental analysis can both help to decide, which trading strategies are appropriate for a specific stock. Fundamental analysis identifies the health of a company and the technical analysis may assist the investor in finding the best entry and exit points for investing in a particular stock. Most large brokerage, trading group, or financial institutions use both analytical models.

Indicators are typically statistical calculations of the stock price or volume. The indicators help to analyze whether a stock is trending and to determine the trend's direction. Often used indicators are Simple Moving Average (SMA), Exponential Moving Average (EMA) and Moving Average Convergence Divergence (MACD).

Technical analysts ignore all other data like company news and economic data. One major assumption of the model is that the stock market price includes all needed information. Another assumption is that price development follows a trend. The third assumption is that trends will repeat themselves in form of patterns. A pattern is a well-defined arrangement of stock price movements.

The technical analysis is based on the study of market activities, such as historical and current prices, volume and some other statistical indicators. The information is used to forecast price movements and trends. The technical analysis relies on charts that visualize the information of a certain stock. It is important to understand that the technical analysis cannot predict future prices. Instead it identifies trends of the price movement. However it can help to identify trading opportunities based on the price trends.

The technical analysis method uses charts, where stock prices are visualized to show stock price trends of the past and of the future. The reliability of the technical analysis is controversial discussed among traders. However, a broad scope of investors such as hobby investors, traders and financial professionals use this method frequently.

The second model is the fundamental analysis. This model looks more directly at the stock company. The goal is to identify the health and the advantages in competition of the stock company. The main principle is stating that fundamental data is much more important than past and current stock prices. A company with good fundamental data will have high stock prices independent of the previous stock prices.

 [Investopedia, 2009] characterizes four main questions of the fundamental analysis. The first question is about the growing of the company's revenue. The second question wants to determine if the company is making profits. The third question asks if the position of the company is strong enough to beat their competitors. The fourth question resolves if the company is able to repay their debts.

Stock market information such as stock prices, volume and stock market indices are being ignored, which is the great difference between the technical and the fundamental analysis.

2.2 Common Stock Charts

There are four major chart types available in finance and scientific literature. Line charts, OHLC (Opening, Highest, Lowest & Closing prices) charts, Candlestick charts and Point & Figure charts are the topic of the following sub sections.

Line charts are most commonly used in newspapers because of their simplicity. Many private traders use line charts. OHLC charts and candlestick charts provide more information than line charts. The additional price information should be better suited for visual analytic tasks of stocks market data. The point & figure chart is a unique stock chart visualization compared to the other three chart types. This chart type indicates only whether the price trend is positive or negative. Actual stock prices are not directly viewable. The visualization is exclusively used by professional chart analysts.

Technical chart analysts have developed a large set of patterns for OHLC and candlestick charts based on the configuration of stock prices. Patterns define distinct sequences of glyphs. Many investors compare stocks and stock market indices with the help of patterns and base their decisions on the pattern. However the correctness of the implications of patterns is not generally accepted by all finance experts.

2.2.1 Line chart

This chart type is the simplest of all four. The quantitative data (i.e. the stock price) is encoded by (invisible) points, which are chronologically connected by lines. Thus each stock is represented by a segmented line. The corners of the segmented line are placed on the chart according to the historical prices of the stock.

The vertical axis represents price values and the horizontal axis represents points in time ascending from left to right. The smallest time unit is usually one day. However exceptions range from the smallest time unit of a minute to an hour, a day, a week, or a month. Intraday investors rely on real time prices and price change information, which are even smaller time intervals.

Each line can only visualize one variable. Therefore only the most important price of the day, the closing price, is shown. [Stevens, 2002] argues that the closing price should be considered as the most important price information in most cases. The closing price refers to the price of a stock from the last trade. Line charts do not provide additional information about the daily price range such as opening, highest and lowest prices.

The line chart in Figure 3 shows daily closing prices of Microsoft stock over a one year time period.

Figure 3: Line chart showing Microsoft stock prices [Yahoo, 2009]

2.2.2 OHLC chart

OHLC (Opening, Highest, Lowest & Closing prices) charts provide additional price information of the opening, highest, lowest and closing prices for each day. The line chart would require four lines to encode the same price information. The charts are used to analyze the historical selling prices of such things as stocks, bonds, and commodities.

The time unit is never less than one day, because smaller time periods are not suitable for representing summary information. OHLC charts are mostly based on daily or weekly or monthly price summaries. As a general rule, short-term traders favor daily time units while long-term traders prefer weekly or monthly time units.

A variation of the OHLC chart is the HLC (High, Low & Close) chart which does not display the opening price. More about the differences and their implications can be read in [Janssen et al. 2009].

OHLC charts use glyphs to visualize stock price information. A vertical line and two small horizontal dashes are used to encode price information. Figure 4 explains the glyphs of OHLC charts on the left side and the glyphs of HLC charts on the right side.
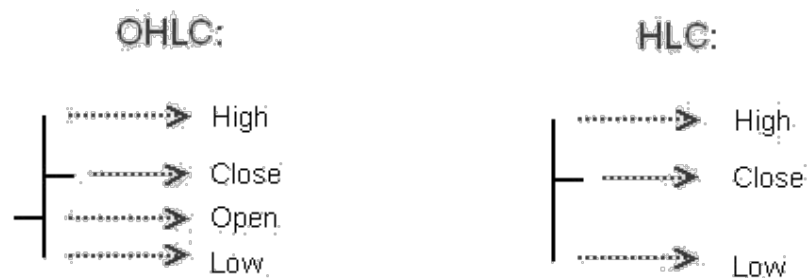

Figure 4: Explanation of OHLC and HLC glyphs

The top end of the vertical line represents the highest price for the trading period. The bottom end indicates the lowest price. The closing and opening prices are represented by two horizontal dashes. The dash on the left side refers to the opening price. Conversely, the dash on the right side refers to the closing price.

Figure 5: OHLC chart of Microsoft stock prices [Yahoo, 2009]

The OHLC chart in Figure 5 illustrates daily opening, closing, highest and lowest prices of Microsoft stocks for a one year time period.

2.2.3 Candlestick chart

The candlestick chart is originally from Japan in the 17th century [Stevens, 2002]. Rice traders used candles to display and predict the rice price. Further information about the history is obtainable in [Hilow, 2009]. The candlestick chart is today very popular in west and east regions of the world.

Like the OHLC chart, the candlestick chart encodes opening, highest, lowest, and closing prices by using a glyph for each data point. However the used glyphs are quite different. The candlestick glyph uses spatial and color visual variables for the display of price information, while the OHLC glyph uses only the spatial class of visual variable.

As shown in Figure 6, a candlestick glyph consists of a colored rectangle which is called the "real body" and a vertical line that represents the price span between the highest and lowest prices. The top end of the vertical line indicates the highest price while the bottom end represents the value of the lowest price.

The real body indicates the price range between the opening and closing prices of the trading period. A black or red color filled rectangle symbolizes that the closing is lower than the opening price. In other words this indicates a negative price trend.

A white or green color filled rectangle indicates that the closing is higher than the opening price. This implies a positive price trend for the time period.
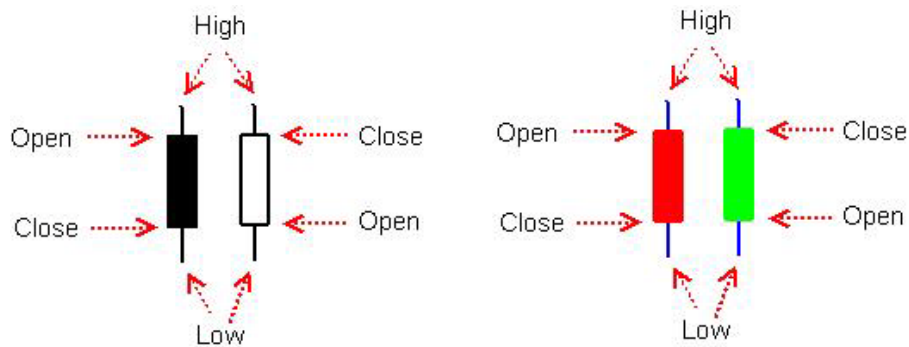

Figure 6: Explanation of the candlestick glyph

The colors are reversed in Chinese finance charts, because the red color represents luck in the Chinese culture. Consequently red color filled real bodies imply a positive trend. The closing price is higher than the opening price. Green color filled real body indicate a negative price trend. The closing price is lower than the opening price.

Candlestick and bar charts are most of the time used for short-term and middle-term investment strategies. Like the OHLC chart it offers more information by encoding four prices. The usage of colors to indicate the price trend is a great advantage of this visualization. The viewer needs less time to analyze the development of the historic prices. A look at the candlestick symbol colors is faster than to compare the left and right dash at the OHLC chart symbols.

The Figure 7 shows a candlestick and an OHLC visualization of the same stock. The time unit is one day. So each symbol summarizes price information about one trading day. Both chart types can illustrate the general trend of the stock price.

By looking at color of the glyphs it can be immediately noticed that the candlestick glyphs visualize the distinction between days with a positive price trend and days with a negative price trend in an effective way. The determination of the relation between the opening and closing price is a simple task. A black color filled real body indicates a negative price trend for the day, while a white color filled real body depicts a positive price trend.
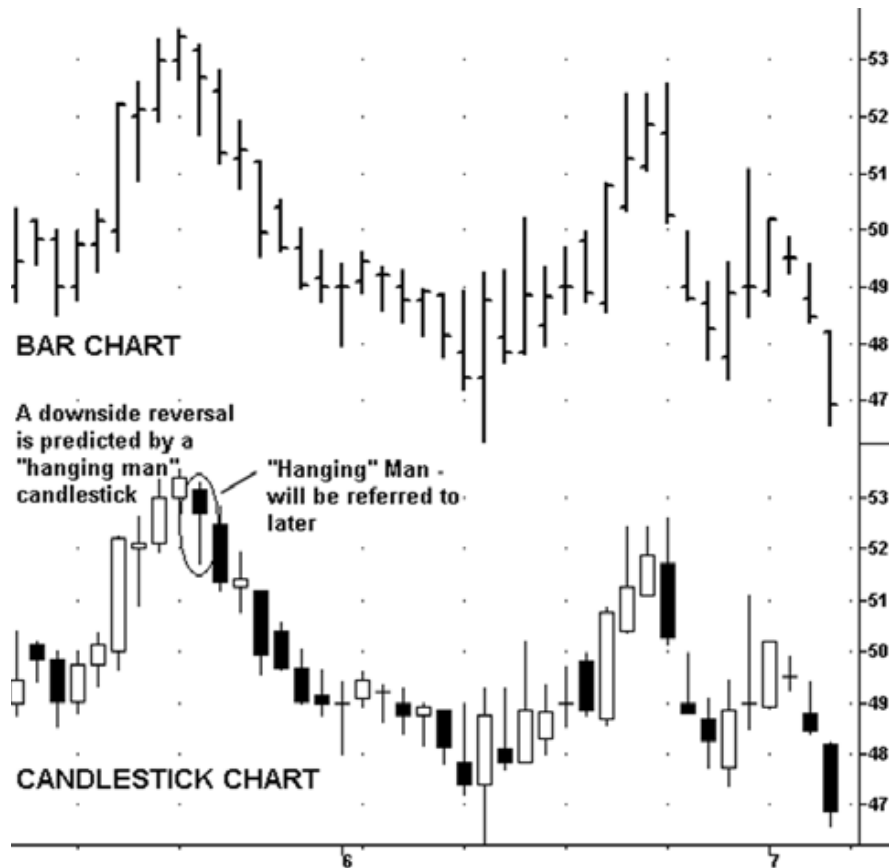
Figure 7: Comparison of OHLC and candlestick visualization [Stevens, 2002]

2.2.4 Point and Figure chart

The point & figure chart is probably the oldest charting technique which is today still in use for chart analysis in the western world. The main idea of this chart type is quite simple. Unfortunately is the resulting chart quite different from the other chart types, which makes the interpretation of the chart a bit unintuitive. The point & figure chart emphasizes on the trends of the historic closing prices.

The most significant difference is the unusual treatment of the time information. Stock market charts usually rely heavily on the relation between time and price value. Charts display time information chronologically from left to right along the horizontal axis with a constant unit scale.

The constant time scale allows easy comparisons. Multiple charts can be compared through the synchronization of the horizontal time unit. The charts are placed in juxtaposition. Another method is a superimposition of the data by overlaying the information of multiple stocks.

Point & figure charts do not allow such comparison methods for multiple stocks, because the time scale is not standardized. However chart technicians use various methods to extract trends from single stock market data and compare only the patterns.

The point & figure chart is composed of a series of columns which consist of either X or O characters. A column of X characters represents a continuous increase of the stock price. A column of O characters represents a continuous decline of stock prices. [Stevens, 2002] and [Investopedia. 2009] provide more examples and further information about Point and Figure charts.

The point & figure chart has two key parameters the "box size" and the "reversal size", which influences the outcome of the visualization. The box size is defining the unit measurement of a price movement. Each X or O character represents a certain price threshold which is defined by the box size. If the price change is less than one box size in either direction, neither an X nor an O character is added to the column.

For instance if the box size is defined as one euro and the closing price changes less than one Euro the price change will be ignored on the chart. But if the price of the stock moves five Euros upwards, five additional X characters will be drawn on the chart.

The reversal size defines the minimum threshold of an opposite price movement before a new column has to be drawn. This parameter can reduce the excessive use of new columns in cases of small price fluctuations.

Figure 8 is a point & figure chart with a box size of one Euro. The reversal size is set to three box sizes which is equal to three Euros. If the price moves in the opposite direction with an amount of less than 3 boxes, the change will not be displayed on the chart.
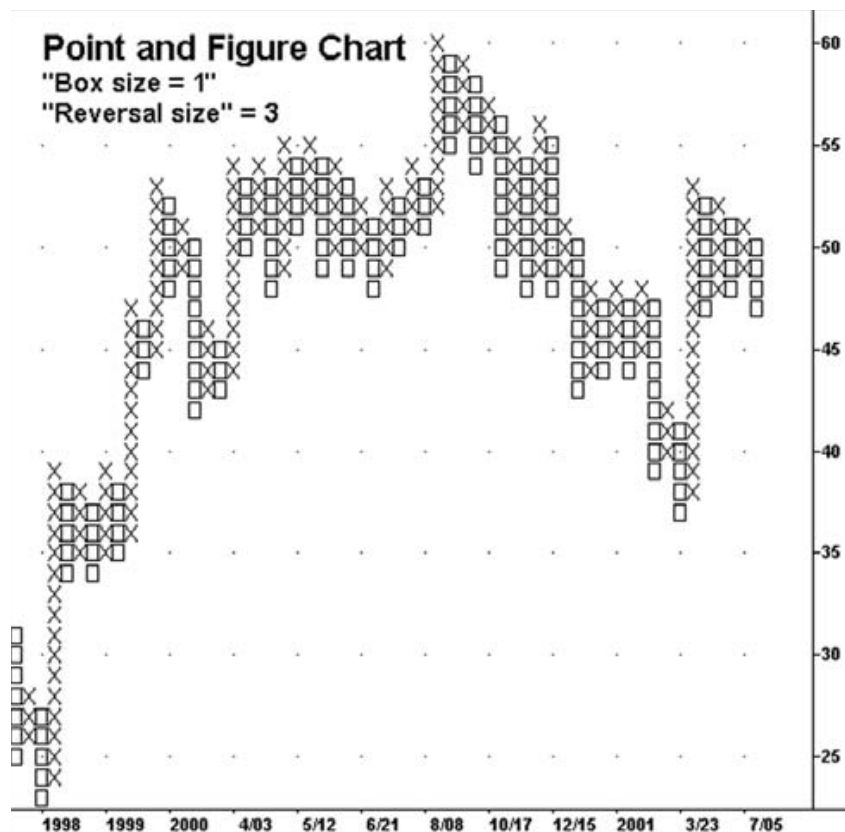

Figure 8: Point & figure chart [Stevens, 2002]

A new column of at least three O characters will appear if the price declines at least three Euros. The new column of O characters begins one box southeast from the last X character of the previous column.

Conversely, if the price moves upwards in the opposite direction, a new column of X characters begins northeast from the last position of the previous column.

The time axis in Figure 8 at the bottom of the chart is clearly not linear scaled. The time periods marked by the ticks are not equal. This is always the case for Point and Figure charts and the reason why visual comparisons of multiple stocks are difficult. The horizontal axis indicates the starting points of significant price trends.

The following points from [Stevens, 2002] are advantages of the point & figure chart over OHLC and candlestick charts. Point & figures charts are

- removing misleading effects of time

- making chart analysis tasks like estimation of support and resistance levels easier

- also making trend line estimation easy

- focusing on long-term price developments

- eliminating insignificant price movements (noise reduction)

Because point & figure charts filter out the noise of minimal or insignificant price movements, every symbol on the chart provides significant information. The information density is much higher than in other charts.

2.2.5 Summary

Four chart types are commonly used for stock market analysis. Each chart type has its own advantages and disadvantages. All charts use the vertical axis for the stock price and the horizontal axis for the time. The price is measured on the vertical axis and time progresses from left to right on the horizontal time axis. The time intervals are typically days, but other time intervals such as minutes, weeks, months and years are also possible.

The line chart is the most commonly used chart. The greatest advantage is its simplicity. Only the most important variable, the closing price, is displayed. This chart is superior for visualizing trends and it also does not use as much ink space as the other chart types.

OHLC and candlestick charts deliver additional price information by the use of glyphs. They provide price information such as

- closing price

- opening price

- highest price

- lowest price

- range of the highest to the lowest price

- range of the opening to the closing price

The trend of the closing price is harder to recognize due the increased complexity of the OHLC and candlestick glyphs. However the glyphs can better indicate the daily difference between the highest and lowest price. High volatility of the daily trading prices is easy to determine. It is not surprising that many technical analysts favor OHLC charts for analyzing stock market data.

Point and Figure charts are somewhat different to the other charts. The time unit is limited in this chart. Only the trend of the closing price is of importance. This leads to a more concentrated display of information, which reduces the complexity of the chart.

OHLC, candlestick and point & figure charts are not suited for superimposition of multiple stocks. This is because of the usage of complex glyphs. Superimposition of the charts would be confusing to the viewer. Only line charts can provide reasonable comparisons of multiple stocks via superimposition.

2.3 Linear and logarithmic scales

Most stock charts display the price information on the vertical axis and time information along the horizontal axis. The effects of the right scale for the chart axis should not be underestimated.

The linear scale is commonly used to display prices on the price axis, because it is the natural way to draw quantitative values. Every equal price interval has the same spatial distance.

The differences between linear and logarithmic scales for stock market charts are explained in detail in [Stevens, 2002]. While in most cases a linear scale is used, a logarithmic scale can improve visual comparisons of percent changes. Line gradients encode information about the percent change when the axis is logarithmic scaled. The gradient is assigned to a certain percent change of the values from the left endpoint to the right endpoint.

Figure 9 demonstrates the differences between the linear and the logarithmic scale quite evidently. On the left side of the figure is a linear scaled axis. The distance between the values 0 and 10 is equal to the distance between the values 10 and 20 and so on. On the right side of the figure is a logarithmic scaled axis. The spatial distances of the price units are exponentially decreasing. The spatial distance between the values 1 and 10 is the largest, while the difference between the values 10 and 20 is much smaller.
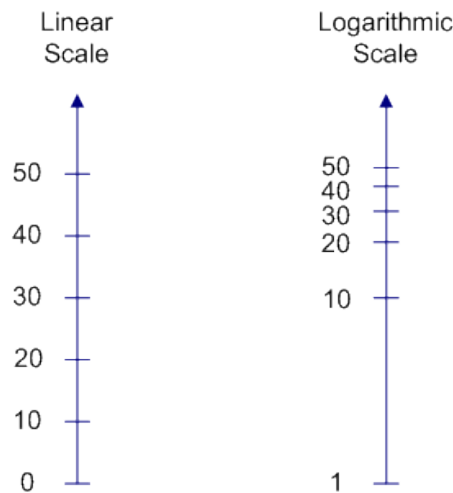
Figure 9: Difference of the unit size between linear and logarithmic scales

Figure 10 demonstrates the disadvantage of the linear scale. It shows two stock prices from company A (blue color) and B (red color) from 1990 to 2000. The stock price of company A changes from 10 to 20, which is equivalent to an increase of 100 %. At the same time the stock price of company B changes from 100 to 200. This is also equivalent to an increase of 100 %. However the two stocks on the chart below have greatly different gradients. Although the percent changes are equal, the gradients are not even near to being equal.

Figure 10: Vertical axis with linear scale

It is apparent that the price development of company B (red color) has a bigger slope than the price development of company A (blue color). This observation may lead to false conclusion about the two stocks. For instance the assumption that the stock price of company B has a bigger percentage increase than stock price of company A is not true.

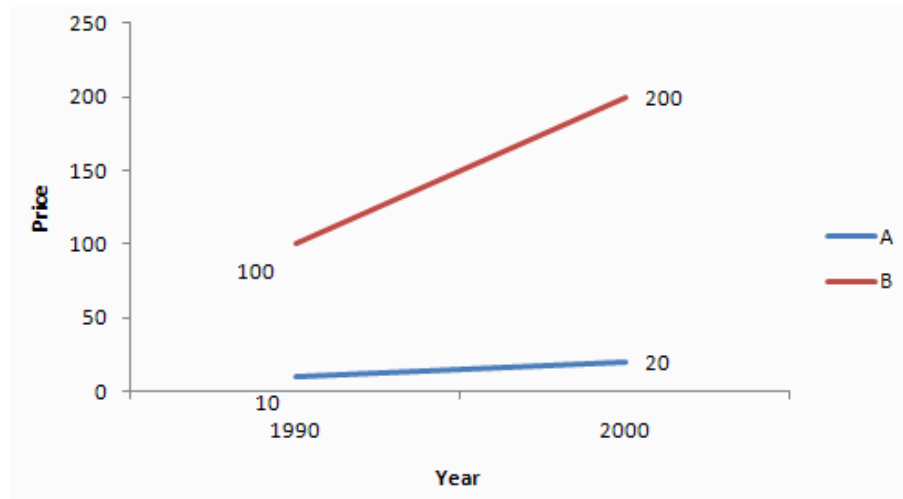Figure 11 shows the same stock prices of companies A and B as before. But this time the vertical price axis uses a logarithmic scale. The lines of both stocks are now parallel to each other, because the slopes are corresponding to the percent change. In logarithmic scales two lines are parallel when the percent change is the same.
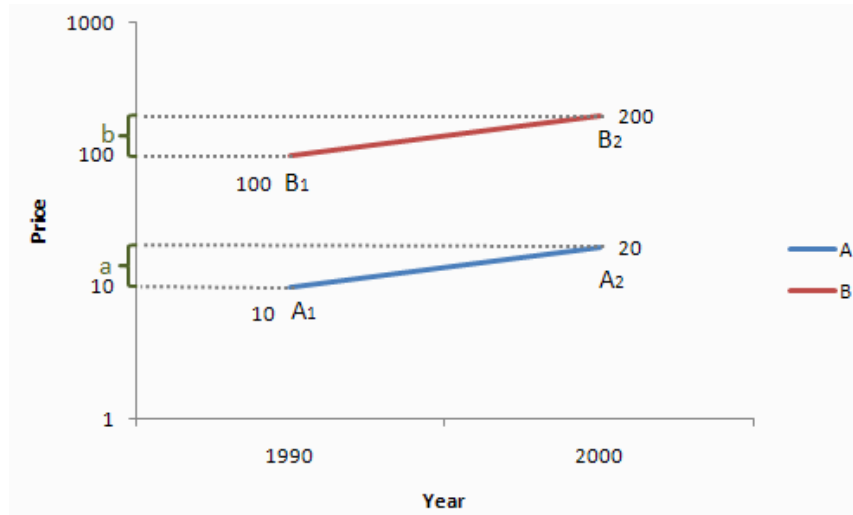
Figure 11: Vertical axis with logarithmic scale

A look at the lengths of the two distances a and b on the vertical price axis in Figure 11 shows that both a and b are of equal length. The distance a is defined as length between the endpoints of line A ($a = \log A_2 - \log A_1$) and b of the line B ($b = \log B_2 - \log B_1$). Both lines have the same percent change.

The following derivation implies that two lines A and B have the same percent change when their gradients are equal. This is based on the assumption that the endpoints A_1, A_2, B_1 and B_2 of the two lines have the same x coordinates or more precisely that the horizontal difference of the two lines are equal.

The second line in the derivation above illustrates the special characteristic of the logarithmic scale. The deltas for the y values are defined by logarithmic values of the y values of the two lines A and B.

If the two lines have the same delta x the gradient of the two lines can be compared by their values for the delta of the y axis. The comparison is simplified by removing the delta x as can be seen in the third line of the derivation below.

The last line of the derivation shows that two lines with equal logarithmic delta distances have the same percent change.

$$m = \frac{\Delta b}{\Delta x} = \frac{\Delta a}{\Delta x}$$

$$\Rightarrow \frac{\log B_2 - \log B_1}{\Delta x} = \frac{\log A_2 - \log A_1}{\Delta x}$$

$$\Rightarrow \log B_2 - \log B_1 = \log A_2 - \log A_1$$

$$\Rightarrow \log \frac{B_2}{B_1} = \log \frac{A_2}{A_1}$$

$$\Rightarrow \frac{B_2}{B_1} = \frac{A_2}{A_1}$$

$$\Rightarrow \frac{B_2}{B_1} - 1 = \frac{A_2}{A_1} - 1$$

$$\Rightarrow \frac{B_2 - B_1}{B_1} = \frac{A_2 - A_1}{A_1}$$

If the delta distance on the logarithmic price scale is bigger for one of the two stocks, then this stock has a greater percent price change than the other stock with the lower delta difference.

This chart is also called semi-logarithmic chart because only the vertical price axis has a logarithmic scale, while the horizontal time scale is linear. Both linear and semi-logarithmic scales are used in technical analysis. Linear scales are adequate for charts which are going back one or two years.

Semi-logarithmic charts are very useful for long-term data analysis where the stock has a great increase, because the logarithmic price scale reduces the needed drawing height in contrast to a linear scaled price axis. Long-term weekly and monthly charts for stock market indices are often better readable with a logarithmic scale, because the values of stock market indices are usually more fluctuating.

In general, logarithmic scaling is best to keep major price changes in perspective. Major gains or losses in stocks are better visualized with a semi-logarithmic scale. The logarithmic scale is often used in comparison tasks for identifying stocks with greater percent changes.

2.4 Volume chart

"Stock chart volume is the number of shares traded during a given time period. […] Volume simply tells us the emotional excitement (or lack thereof) in a stock." [Swing, 2009]

An important indicator of stock market data analysis is volume. Volume is usually displayed by a column diagram under the price chart. The visual height of each column indicates the interest degree in a stock on a certain time point. If a stock was traded on high volume, then there was great interest in this stock. Conversely if a stock was traded on low

volume, then the stock trader had not so much interest in it. The Figure 12 shows an example of ne year volume for Microsoft stocks.
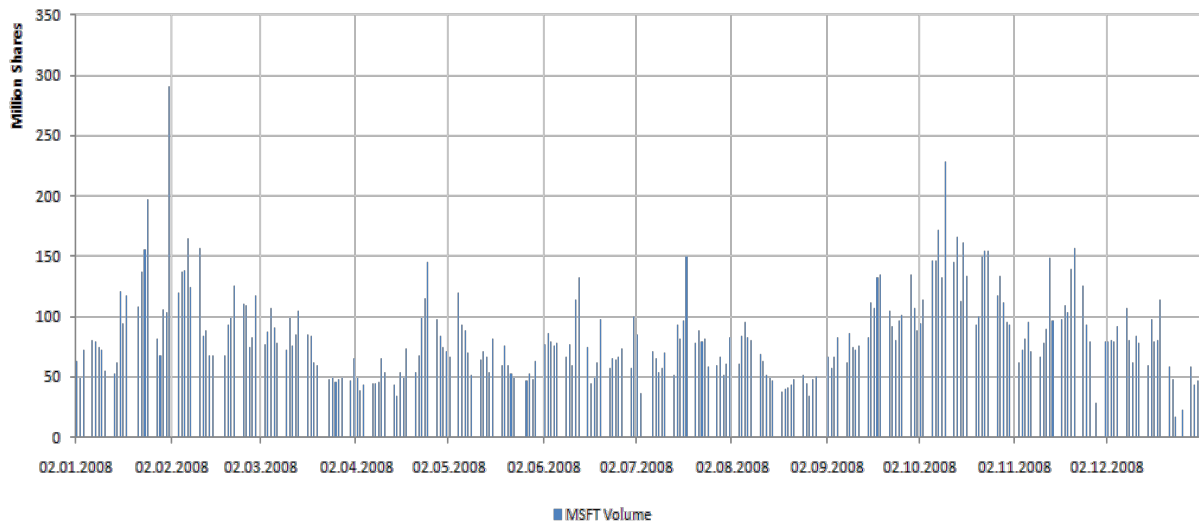

Figure 12: Column chart depicting volume information

Volume information is always plotted via a column chart, where each column represents the amount of traded stocks for a day or sometimes other time units like weeks or months depending on the needed granularity of the volume information.

Stephen Few describes the outcome of bar or column charts as emphasizing on individual values. *"Bars do one thing extremely well: due to their visual weight, they stand out so clearly and distinctly from one another that they do a great job of representing individual values discretely."* [Few, 2004]

Line charts are less qualified to encode the information properly. According to [Few, 2004] line charts are well suited to encode quantitative values in two particular ways. The lines connect individual data points into an ordered sequence and they excel at the visualization of inherent trends within the data series.

Figure 13 shows the same volume information with a simple line chart. The axes and their range are equal as the previous column chart. As you can notice the line chart displays value changes over time very well. But the line chart is not very capable for comparing single values associated with the individual points. It is harder to compare values for individual days, than when using a column chart.
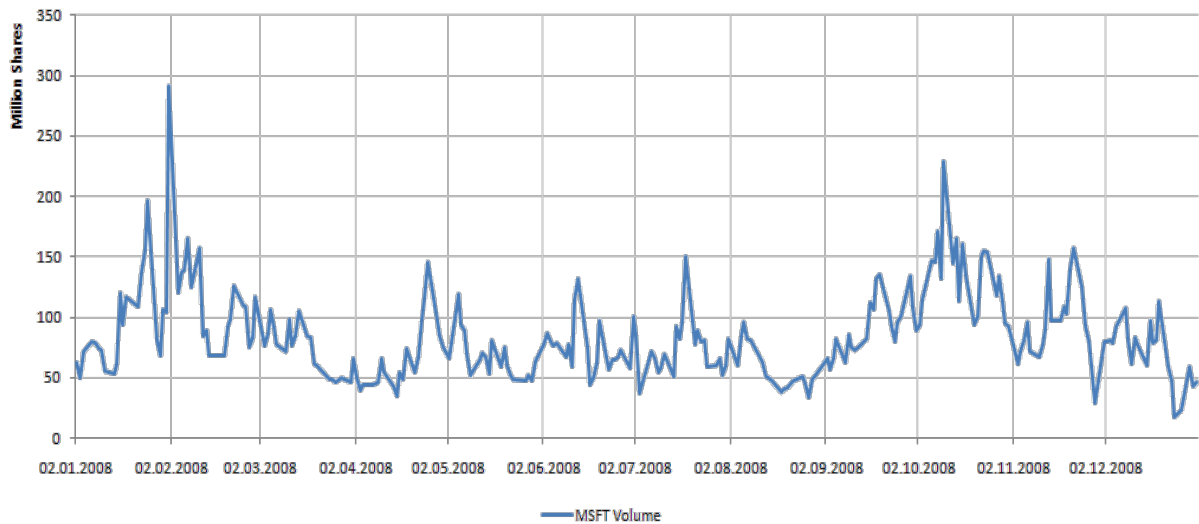
Figure 13: Line chart depicting volume information

The plot in Figure 14 uses points to encode the quantitative information. Values of individual points are better viewable but the sequence of time is lost. The points do not visualize the sequential relationship of time between individual points very well.
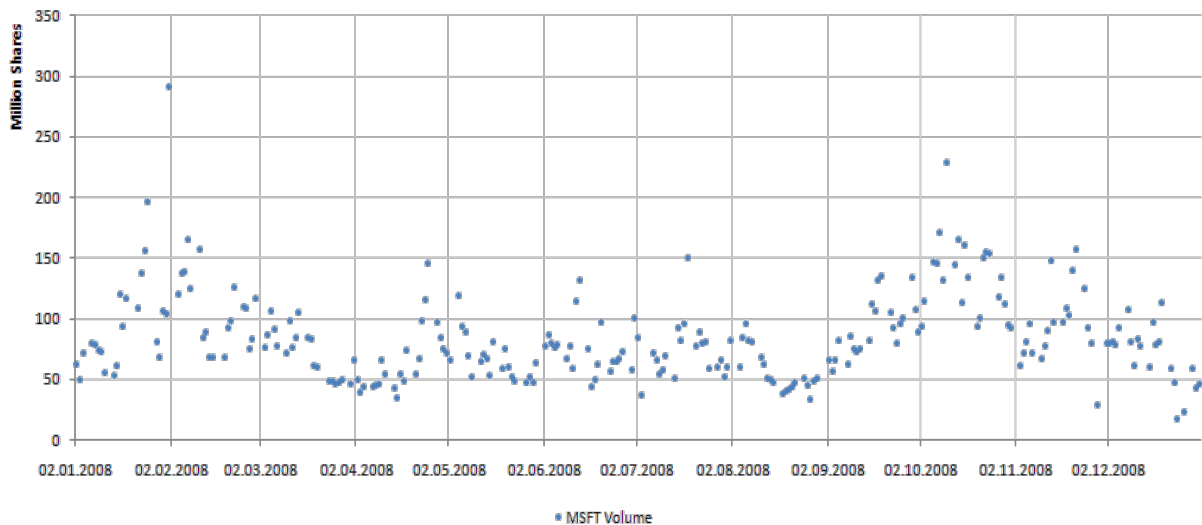
Figure 14: Chart depicting volume information through points

The sequence of points of the plot in Figure 14 can be restored by connecting adjacent points. The resulting point and line chart allows the user to detect value changes easily and visualizes the natural flow of time at the same time. The Figure 15 illustrates the chart.
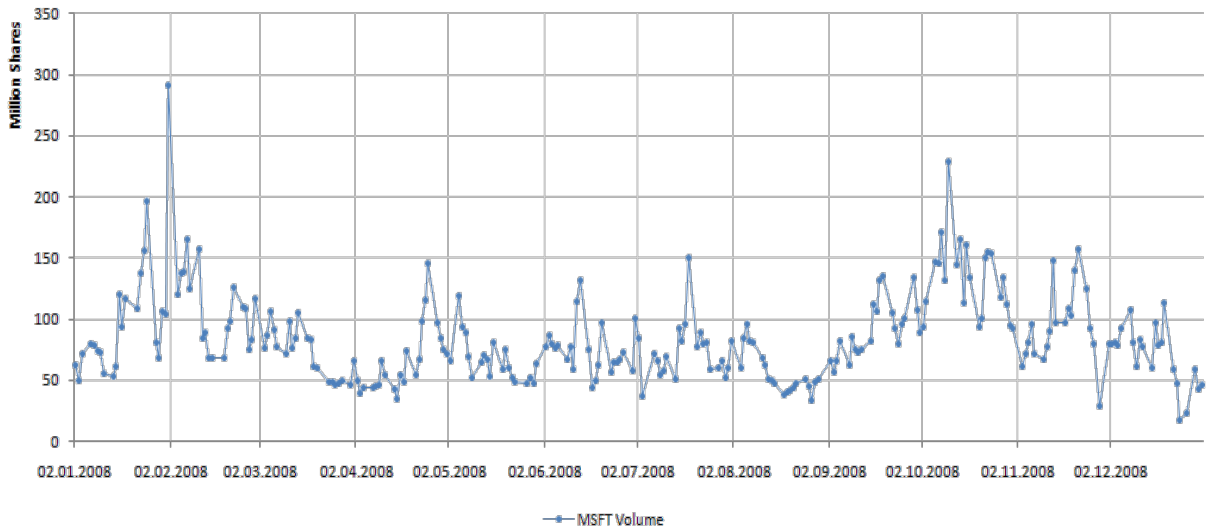
Figure 15: Line chart with points depicting volume information

However, only the column chart is commonly used for encoding of volume information. Individual values are generally better encoded by bars or columns. Relative changes and trends are not so much important for volume data. The line chart provides only a suboptimal solution. Point visualizations are lacking the visual representation of a sequence of data items.

2.5   Comparison Methods for Stock Market Data

There are generally two simple methods available to compare multivariate time series data:

- Superimposition of time series: All time series are overlaid in one diagram. Useful if all time series have the same unit. Limited when multiple units are involved.

- Juxtaposition of time series: All the time series are compared by using separate diagrams for every time series. It is more suitable for complex data like OHLC and candlestick charts. Not limited by multiple units although comparisons between values of different units are certainly ambiguous.

Time series are mostly visualized by line charts. Multiple time series are often compared by juxtaposition. This method is much more independent. The user can look at single time series and concentrate on the development. It does not enforce a visual comparison like the superimposed line chart.

Another problem of superimposition is the reduced readability the more time series are displayed. The chart gets clustered with information, which takes more effort to read and can lead to confusion.

On the other hand the superimposed chart greatly reduces the needed space. Each juxtaposed chart requires additional space, which may be limited. Juxtaposed comparisons are also limited by the alignment. Two charts can only be directly compared when they are

located beneath each other. The more time series have to be compared the further away are the charts on average, which limits the efficiency of the comparisons.

Another method to compare stock market data is to use special visualizations like sparklines. The concept originates from the famous visualization expert Edward Tufte. The visualization can reduce the problem of big distances between juxtaposed charts. Horizon graphs are similar, but are more sophisticated.

Jacques Bertin proposed a method to compare multivariate time series more easily. The indexing method transforms the original values into percent values.

Treemaps can be used as visualization for stock market data to compare numerous stock prices at once. The visualization can even include hierarchical structure about the data.

2.5.1 Sparklines

Edward Tufte developed the concept of small multiples around 26 years ago. *"Small Multiples are small, thumbnail-sized representations of multiple images displayed all at once, which allow the reader to immediately, and in parallel, compare the inter-frame differences."* [Tufte, 1983].

Small multiples are well suited for comparisons of a great number of variables. The size of each time series has is much smaller which reduces the average distance between the visualizations.

Sparklines are roughly based on the concept of small multiples, which he defined 23 years later. He describes them as *"[...] small, high-resolution graphics embedded in a context of words, numbers, images. Sparklines are data-intense, design-simple, word-sized graphics."* [Tufte, 2006]

Figure 16: Exchange rates visualized by sparklines [Tufte, 2006]

Sparklines are well suited to display financial data. As show in Figure 16, the sparklines only require a relatively small space to display a time series. All sparklines in the same column are synchronized and share the same time span.

The vertical range is not equal for all. The range depends on the actual values which have to be displayed. This does not necessarily have to be a disadvantage. The emphasis of sparklines is not to present exact values but rather to visualize the historic development and the relative change of the time series data.

Sparklines can include further quantified information by highlighting important positions of each time series. The values are written next to the sparklines visualization.

Tufte gives an exemplary arrangement of the sparklines and four important values in Figure 16. Each sparkline is accompanied by four columns:

- The first column shows the start value and is located at the left side of the sparkline.

- The second column shows the end value and is located at the right side of the sparkline.

- The third column shows the lowest value and is located next to the second column.

- The fourth column shows the highest value and is located next to the third column.

Because each sparkline occupies just a relative small space, many sparklines can be compared by juxtaposition. Sparklines are thus able to display of financial data for comparisons very effectively and in a simple way.

2.5.2 Horizon graph

The horizon graph is a quite new visualization. It was created by the Swedish company Panopticon Software as part of their business intelligence application.

The idea is similar to the sparklines visualization. The goal of the horizon graph is to display many time series in juxtaposition for comparison purposes. Both comparison methods are able to proceed where standard juxtaposed line charts are not useful, by reducing the required size. Similar to the sparkline visualization are exact values not of great importance. The visualization of trends and relative changes are key objectives of the horizon graph.
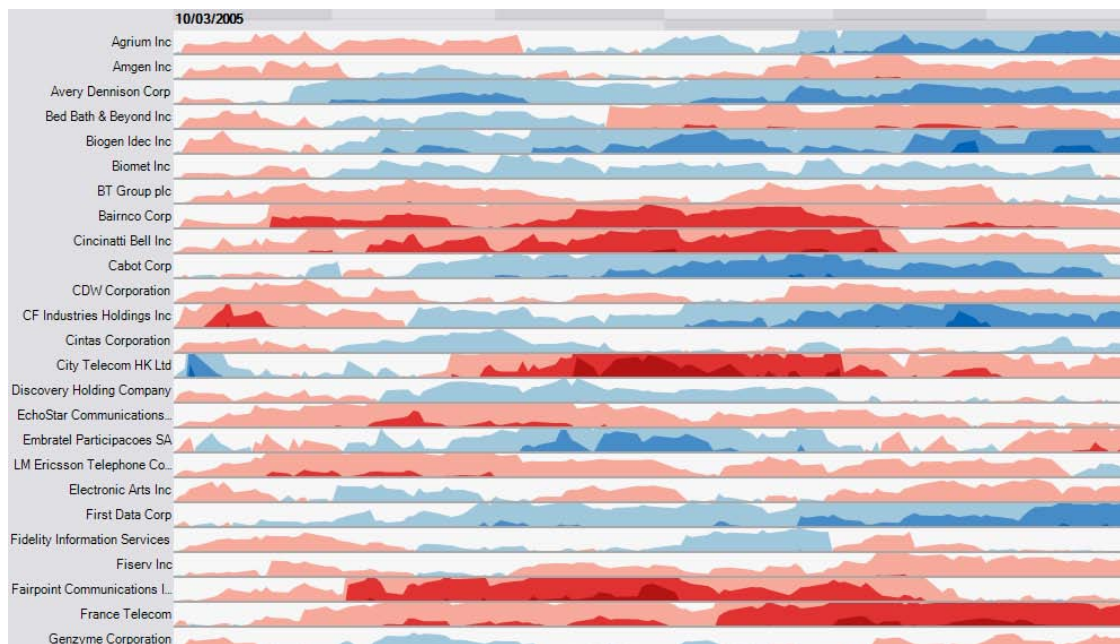

Figure 17: Horizon graph visualizing 25 stocks [Few, 2008]

Figure 17 is a screenshot of a horizon graph consisting of 25 stocks. All variables of the horizon graph are horizontally aligned. Otherwise comparisons between various variables would not be possible. The values for the y-axis are represented by two visual variables spatial position and color intensity.

The color red indicates negative values, while blue indicates positive values. The values are layered into bands according to certain value ranges. Each layered band has is mapped to a certain color intensity. Lower ranges match lighter shades while more extreme value ranges match darker shades.

Figure 18 shows the construction of the horizon graph based on the original line chart. The fillings are colored according to the value range or bands. The bands are layered in the next step. The last step is to mirror or to offset the negative values, which reduces the needed height by half.
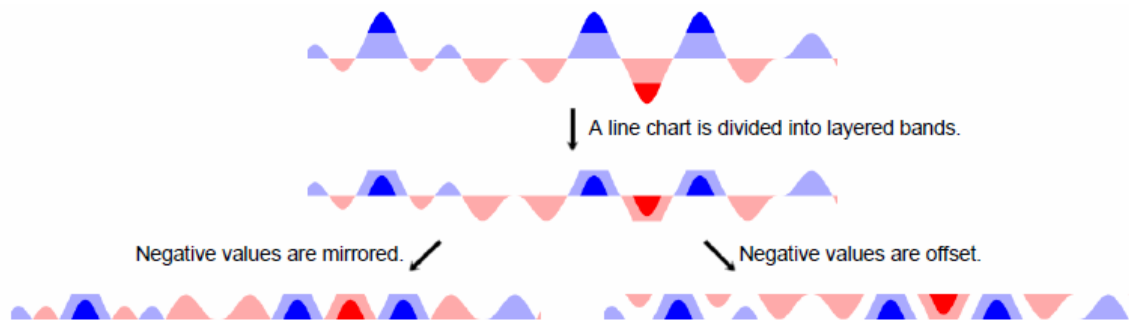
Figure 18: Construction of a horizon graph. At top the line chart is divided into bands. Then the bands are layered. Third the negative values are mirrored (left) or offset (right) [Heer et al., 2009]

The horizon graph is based on the line chart. The transition steps from a simple line chart to the horizon graph are fully described in [Few, 2008].

[Heer et al., 2009] gives a great introduction of the visualization and provides extensive test results about the horizon graph. He concludes that mirroring of negative values does have no negative effects and layered bands are beneficial when size of the visualization decreases.

2.5.3 Indexing

The French visualization pioneer Jacques Bertin originally proposed the indexing method in his famous book Semiology of Graphics [Bertin, 1983]. This comparison method is intended to compare multivariate heterogeneous time series data.

Multivariate time series can be compared by superimposition if all variables share the same unit. If this is not the case multiple vertical axes can be used to achieve superimposition of heterogeneous time series. However the use of multiple units and axes can lead to misunderstandings. This is a result of the arbitrary relations between the axes. Cross points be-

tween time series do not have any meaning, because they are just the product of the arbitrary selection of the axis ranges. Juxtaposition is in most cases the only solution for comparison of heterogeneous data.

The indexing method avoids this problem by using a simple transformation for the original values for each time series. The result is a set of new values of a percent unit. The heterogeneous time series are converted into homogeneous data, which can easily compared by superimposition.

Bertin defines the indexing method with the following formula:

$$index_n = \frac{Q_n}{Q_i} * 100 \ [\%]$$

The new indexed value is calculated for every element in the original time series. The point i refers to the indexing point. This is a special point of the time series. It is the base point for all percent calculations. The index value for the point n is thus calculated via the formula described above. Q_i is the value of the indexing point and has always as result the value 100 %. Q_n is the original value of the time series.

The indexing method offers many advantages. Unlike the other comparison methods it is applied at the data itself. The transformed values can be used for any visualization. Line charts are a possible visualization but the indexing method is not restricted to this visualization.

Another advantage of the indexing method is that different value ranges do not affect the readability. For example two different time series should be compared. One series has on average relatively low values and the other series has on average relatively high values. A comparison has to include the axis range which includes the extreme values for both time series. The displayed data is usually distorted, because of the great value range of the price axis. As a result both time series look flattened, which looks like the values do not change a lot. Such distorted representations can easily lead to false conclusions.

Indexed values emphasize percent changes based on the indexing point rather than actual values. Therefore the time series will not look distorted and flat.

The indexing method is perfect for comparison of percent changes. This is especially true for financial data like stocks. The stock price refers to the price of a single share. The key of stock trading is the percent change and not the absolute price of a single share.

Figure 19 shows a superimposed line chart of three stocks AAPL, IBM and MSFT over a one year time period. The indexing point is set to be the starting point. This is perfect to compare the performance (i.e. percent change) over the year.

Although all three stocks have lost some of their value, it is clearly visible that IBM has lost the least percent amount. At the end of 2008 AAPL has an indexing value of around 45%, MSFT of about 55% and IBM of about 80%. Hence AAPL has lost 55% of its value in the year 2008. IBM has the lowest percentage loss of the three stocks with about 20%.
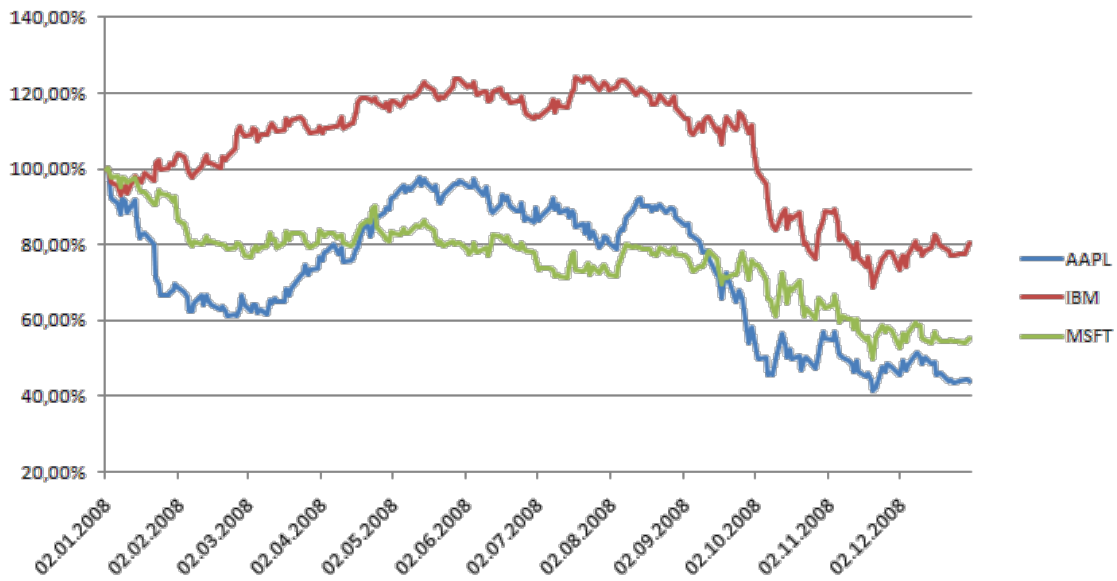
Figure 19: Line chart using indexing method with the indexing point set at the beginning

Another interesting feature is that the indexing point can be freely chosen from all available points of the time series. The effect of the selection of an indexing point is visually very different as the following figure will show.

Figure 20 displays the same data as before but the indexing point is set at 03.03.2008 instead of the starting point. At the end of the year 2008 all three stocks have an indexing value of around 70%. This implies that all the three stocks have lost around 30% from March to December.

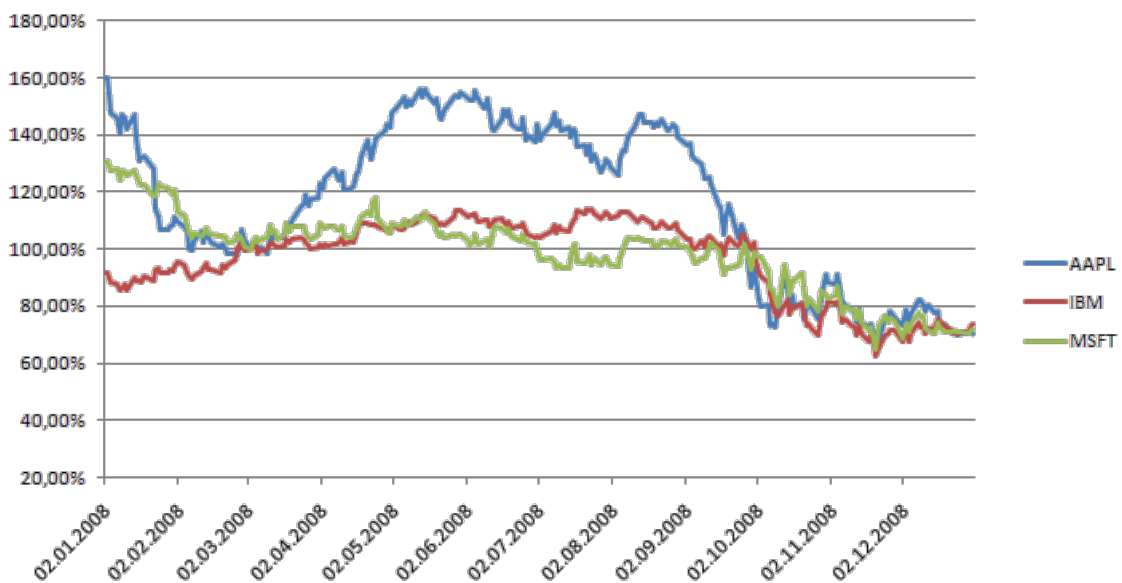**Figure 20: Line chart using indexing method with the indexing point set at 03.03.2008**

The choice of the indexing point is useful for comparisons for a given time period. For instance the date when an investor buys could be set as indexing point. It is very easy to recognize and compare percent changes of the stock against others in this way.

2.5.4 Treemap

Johnson et al. [1991] and Shneiderman [1992] describe another potential visualization for stock market data. The treemap visualization is an another advanced comparison method for multiple time series which can also contain hierarchical information.

"The Tree-Map visualization method maps hierarchical information to a rectangular 2-D display in a space-filling manner; 100% of the designated display space is utilized. Interactive control allows users to specify the presentation of both structural (depth bounds, etc.) and content (display properties such as color mappings) information." [Johnson et al., 1991]

Figure 21 displays the schema of a typical treemap. Each variable is represented by a rectangular area on the graph. The size of the rectangle is usually related to the value of the variable. The common treemap uses a slice-and-dice layout, which includes mostly rectangles with a high aspect ratio.
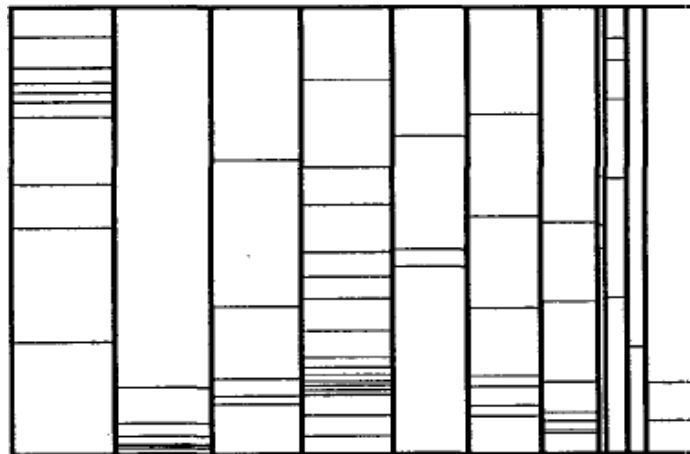
Figure 21: Slice-and-dice layout of a typical treemap [Wattenberg, 1999]

The treemap can be applied for financial data such as stocks. Stocks can be classified into stock sectors, where the companies of similar industries will be put together. The hierarchical information can be easily visualized with a treemap. Each rectangle represents a stock company. A composed rectangle represents a stock sector. The size of a rectangle can be determined differently. For example the size could be according to the market capitalization of the stock. The market capitalization is calculated by multiplying the amount of share times the stock price. Green and red colors can be used to encode positive and negative price changes.

Wattenberg proposes in [Wattenberg, 1999] an advanced treemap display method. It is intended for better recognition of stocks and thus enabling easier comparisons of stocks.

The problems of the high aspect ratio of the previous treemap can be solved with the treemap in Figure 22. An algorithm is used so that always rectangles with moderate aspect ratio are created. The result is called squarified layout. It is easier for comparisons of stocks and enhances zooming.

Another benefit of the display method is the gain of information of stock development based on industry clusters or stock segments. Similar stock companies are placed beside each other forming clusters of similar stocks.

At first the desired stock market has to be chosen. Next each stock of the market has to be assigned to a certain stock sector. Examples may be a technology sector, financial sector, services sector, industry sector and basic materials sector. At last the space of each stock has to be determined. An example could be to define the space of the rectangles according to the market capitalization.

Figure 22: Treemap visualization with reasonable aspect ratios for every rectangle [Wattenberg, 1999]

The original treemap visualization is not intended to display correlations between stocks. [Wattenberg, 1999] describes a simple algorithm which produces a layout according to similarity of the stocks instead of stock segment clusters. The calculation of similarity is based on the monthly percent price changes of the stocks over a three year time period. Thus every stock has 36 spatial points (one point for each month). The similarity between two stocks is measured through the Euclidean distance from these points. A high degree of similarity can be achieved by minimizing the square root of the sum of all spatial point pairs.

The resulting treemap makes comparison easier and more effective. Similar stocks are placed closely and the algorithm creates approximately square rectangles of the stocks. The

similarity between neighbors may help to get more insight of the data such as the identification of trends, patterns and correlations.

Other successful adaptations of treemaps for financial application can be found in [Smartmoney, 2009] and [Finviz, 2009].

2.6 Summary

Finance literature distinguishes between two analytical models for stock analysis. The technical analysis concentrates on stock prices and volume information. Indicators based on statistical calculations provide additional information for the technical analysis. The fundamental analysis is based on a broader scope of data about the company itself. The fundamental analysis checks the health of a company, while the technical analysis helps to determine entry and exit points of investments.

The four most common stock market visualizations are the line chart, OHLC (Opening, Highest, Lowest & Closing prices) chart, candlestick chart and the Point & Figure chart. Line charts are ideal for analyzing trends of the data and allow comparisons by juxtaposition and by superimposition. OHLC and candlestick charts represent additional price information by using glyphs. But the drawback of the complex glyphs is that they are not suitable for comparison by superimposition. The Point & Figure chart visualizes only the trend of the stock price. The time unit is irregular depending on the trend and trend reversals. Therefore even comparisons by juxtaposition are hard, because the time values of two stocks cannot be synchronized.

The price axis is often linear scaled. The spatial size between equal price units is constant for all values. The size between equal price units of a logarithmic scale is exponentially decreasing. The slope of a line is representing the percent change of the two endpoints. This makes percent comparisons easy and more precise.

Volume information is commonly displayed via a column chart. The reason is probably the focus on individual values, rather than to visualize the trend of the volume, which is not of importance. Other presented visualizations are the line chart, point chart and the line & point chart are not as effective for the visualization of volume data.

Simple comparison methods of multiple time series are juxtaposition or superimposition. An advanced comparison method for line charts is indexing. The indexing method transforms the original values into values of relative changes according to an indexing point. Other advanced visualizations for comparison of multivariate data are sparklines and horizon graphs. Both reduce the needed size of the visualization and compare the data by juxtaposition. Treemaps can be used to display stock market data. However the comparison is limited to recent percent changes. But an advantage is the visual representation of hierarchical information of the stock market data.

3   State of the Art: Web Applications

This chapter gives an overview of a few selected and promising web applications which display stock charts. The applications use different visualization methods which may be a result of the different main customer groups.

This chapter focuses on web applications because they are accessed by a large group of typical private investors. The data is often in real time and the service is free.

3.1   Der Standard

"Der Standard" [derStandard, 2009] is the name of a rather popular news magazine in Austria. The news paper covers several areas form politics to economics, sports and culture. The online magazine shows stock information in relevant news articles of companies. The following figure is taken from an article about General Motors (GM), one of the biggest car companies of the world.

Figure 23: Simple view of GM and FMC stocks [derStandard, 2009]

The Figure 23 shows a comparison of the prices changes for GM and another car company, Ford Motor Company. The reader can instantly notice the current stock prices of both companies. Both stocks are traded at the New York Stock Exchange (NYSE). The price of both stocks and the percent change between the last and the displayed value is shown. The percent change is written in red for negative changes and green for positive changes.

The figure provides only a very limited scope of stock market information. Another issue is that the stock prices are somewhat ambiguous, because no reference date is specified. It is not clear what date the price is referring.

It is fortunate that the online news magazine does provide further information. The news reader can watch more in-depth stock market information by clicking on the name of the company.

The Figure 24 illustrates the more detailed view of the General Motors stock. This information is displayed when the user clicks on the link of General Motors in the previous figure.

It should be noted that the technical data of only one stock is shown. Therefore comparisons between multiple stocks are not directly possible.
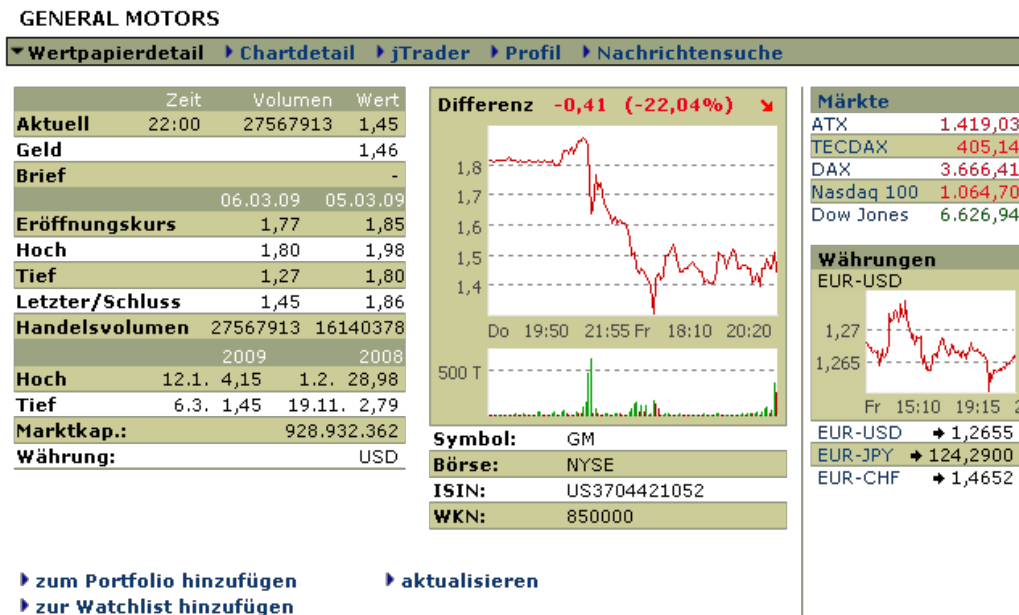
Figure 24: Detail view of General Motors stock [derStandard, 2009]

The display is divided into three columns. The left column provides numeric information of opening price, highest price, lowest price and last respectively closing price and volume for the actual day and the day before. The yearly highest and lowest stock prices of the current year and the year before are also included. The market capitalization, which belongs to the fundamental data, is also available.

The middle column shows the intra-day development of the stock price of the actual day and the day before. Below the stock price chart is the volume chart located. The time axes of both are synchronized.

The right column summarizes the current values of major stock indices. Similar to the previous figure are positive changes written in green color and negative changes in red color. A smaller line chart depicts the exchange rate of Euro to US-$. Three other exchange rates are also shown.

The user has also the ability to add the stock to a personal portfolio. This is a collection of favorite stocks for an easy lookup at later times.

The major disadvantage of the application is the limited comparison features. Only the simple view compares two stocks. The user has no function to define which stocks should be compared. Besides only the closing price and percent change are available, which is insufficient.

Comparison of multiple stocks is only possible through juxtaposition. This can be achieved by opening multiple browser windows, where each window shows the detailed view of one particular stock. The user has to switch between the windows to compare values. Price ranges and scales of the price axes are dependent on the stock price, which makes any attempt of conducting a visual comparison inaccurate.

3.2   Google Finance

Google Finance [Google, 2009] is a professional web application for finance data. The user interface is well designed and interaction is quite intuitive.

The application provides a lot of technical and fundamental information. Technical stock data includes a real time stock price, absolute and relative changes in green color for price increases and red color for price decreases. Other fields provide information about opening, highest and lowest prices and volume.

The available fundamental data spans over a broad range of various indicators. Examples are market capitalization, P/E ratio (price-to-earnings ratio), dividends and EPS (Earnings per share). Another interesting information sources are relevant news headlines, which are displayed next to the chart.

The Figure 25 shows the main view of the Google Finance application. The actual / last price is placed strikingly in the top left corner. Next to the stock price are absolute and relative price changes in green or red color, depending on the price change. Green indicates that the current price is higher than the closing price of yesterday. Conversely red color indicates that the closing price is lower than the closing price of yesterday. The user can quickly know where price fell down and when the price rises up.

At the top right corner are current value and the daily change of important and relevant stock indices displayed. A color-coded bar chart provides graphically the percent changes. This part is well suited to recognize general trends and correlations of important stock markets.
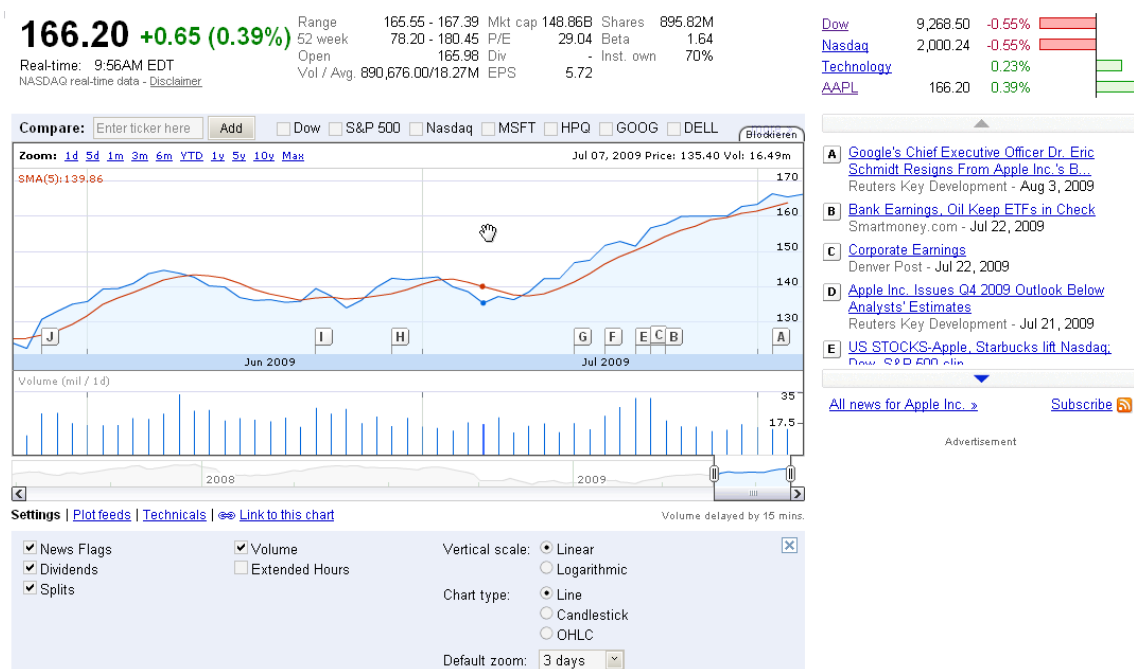

Figure 25: Google Finance – Overview [Google, 2009]

Below the visualization are some settings available. The user can choose either a linear or a logarithmic scale for the vertical price axis. It is also possible to switch between three available chart types: line chart, bar chart and candlestick chart. The display of miscellaneous information can be enabled or disabled. Available events and information are news flags, dividend payments, split events, display of volume and extended hours.

A rich collection of useful technical indicators can be enabled. Some examples are simple moving average, exponential moving average, moving average convergence divergence, bias ratio and so on. Those indicators are available for price development and for volume development as well.

Figure 26 shows the standard line chart visualization. On top are relevant stocks which can be added to the chart by clicking on the proper checkbox.

Figure 26: Google Finance – Line chart visualization [Google, 2009]

Google Finance offers innovative and interactive stock market visualizations. The interaction methods are highly sophisticated and provide many well-thought-out innovations. Two valuable interactions zooming and value displaying based on mouse cursor location will be explained in the following paragraphs.

There are several methods available to zoom in and out. At the top left corner are some common used time ranges like 1 day, 5 days, 1 month, 3 months, 6 months and so on. The mouse wheel is able to increase or decrease the displayed time range, which is also a standard interaction method.

Below the volume chart is another interactive zooming method. The user can set the zoom range through a simple drag and drop operation of the boundary elements. The user can also move the zoomed time range by dragging the scrollbar to the left or right at the bottom of the visualization.

Figure 27: Google Finance – OHLC chart visualization [Google, 2009]

Above the chart at the right side is the legend placed. It shows values for all displayed stocks and / or stock market indices based on the actual mouse position. This enables an easy lookup of values for a given day. The horizontal position of the mouse cursor is decisive for the selected date. The selected date is marked by a small dot.

The integration of news headlines as news flags on the chart is another useful feature. It can be used to discover any effects or relevant news information to the development of the stock price. This feature is a tool to identify past trends. It is probably not intended to influence any predictions of future stock prices.

Figure 28: Google Finance – Candlestick chart visualization [Google, 2009]

All news events are listed on the right side next to the diagram. Each headline is assigned a distinctive letter, which are chronologically sorted. The flag on the chart is linked to the

news item. If the user clicks on a news flag, the related news item in the news list are highlighted. The user can open the news article and get more information.

Google Finance is also able to compare multiple stocks and / or stock indices by superimposition. The Figure 29 shows stock prices of two stocks from Apple and Google and of the stock market index NASDAQ.

This visualization is using a limited version of the indexing method. However the indexing point is always set at the beginning of the displayed time period. Thus all visualized time series start at the same value 0 %. A horizontal reference line marks 0% through the whole chart. This is useful for the user to recognize fast positive and negative percent changes.

Figure 29: Google Finance – Comparison of multiple stocks [Google, 2009]

Multiple time series are automatically transformed to display percent changes. The price axis changes the unit from the default currency of the stock to a percent unit. The comparison of percent changes is much more effective for stock analysis, because stocks do not have a common base price.

The legend on the right side above the chart shows the percent values for every stock depending on the mouse position. There is no limit for the amount of stocks.

The only disadvantage of Google Finance is the limitation of the fixed indexing point to the start value. This is certainly a reasonable default setting, but it would be even better if the user could set the indexing point as he or she wishes. It is a pity because it would probably be very easy to include such a function to manually define the indexing point.

3.3 Yahoo Finance

Yahoo Finance [Yahoo, 2009] is a popular web application by Yahoo Inc to provide financial information such as stock quotes, stock exchange rates, corporate press releases and financial statements, company events, key economic data of companies, analyst opinion and estimates, message boards for discussing company and stocks.

Yahoo Finance offers three different charts to show stock price and volume information. The three charts are referred in the following text as basic chart, basic technical analysis chart and interactive chart. As the name already implies are the first two charts static. The two static charts offer only a restricted set of interactions of clicking on a link or button.

All three available charts can display stock market data with lines, bars or candlesticks. The scale can be set to linear or logarithmic. Also the most common time periods can be selected. The displayed time range can be 1 day, 5 days, 3 months, 6 months, 1 year, 2 years or 5 years.

Figure 30 depicts the basic chart with stocks of Apple and Microsoft. There are two sizes for the chart to choose from middle and large. It also offers an easy method to compare the current selected stock with another stock or stock indexes such as S&P, NASDAQ and Dow Jones.

Figure 30: Yahoo Finance – Line chart visualization [Yahoo, 2009]

Many functions like the default zoom ranges, the selection of the chart type and scale are similar to use as in Google Finance. Relevant stocks and / or stock indices can also be added and removed in a similar manner as in Google Finance.

Multiple time series are compared by superimposition. However the comparison visualization is a little bit confusing. The primary selected stock can be displayed by a line, OHLC (Opening, Highest, Lowest & Closing prices) or candlestick symbols. The secondary and further stocks are always drawn as line. OHLC and candlesticks are not well suited for superimposition. Too many details would be poorly readable.

Figure 31 shows a candlestick representation of the primary stock of Apple (blue color) and the secondary stock of Microsoft (red color) is represented by a line. This comparison is limited because the two stocks are visualized by different visual items. A candlestick glyph displays opening price, highest price, lowest price and closing price while the line chart displays only the closing price.

A better solution for comparison of multiple stocks and / or stock indices would be to display both stocks by lines, which is also the approach of Google Finance for comparisons of multiple stocks.

Another disadvantage of Yahoo Finance is that the comparison view does only provide percent value information. It is unfortunate, that the actual stock prices are never viewable.

Figure 31: Yahoo Finance – Candlestick chart visualization [Yahoo, 2009]

The basic technical analysis chart is based on most parts on the previous described basic chart. Additional functions are the display of finance-statistical indicators such as Moving Average (MA), Exponential Moving Average (EMA), Moving Average Convergence Divergence (MACD) and other similar indicators.

The Figure 32 shows the settings menu with all available attributes. Each time when an attribute is changed the whole page will be reloaded. After the page has finished loading other attributes can be changed in the same way. This procedure can sometimes be a bit slow when a lot of attributes have to be changed.
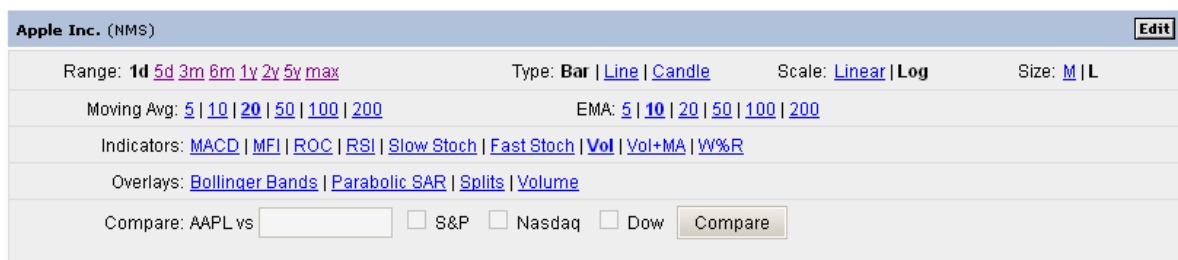
Figure 32: Analysis menu provides an extensive set for customization [Yahoo, 2009]

The visualization of the basic technical analysis chart is the same as the basic chart. The following figure shows a comparison of Apple against Microsoft stocks. The primary stock of the visualization Apple is displayed by blue OHLC (Opening, Highest, Lowest & Closing prices) symbols. The secondary stock of Microsoft is only showing closing prices which are drawn as a line.
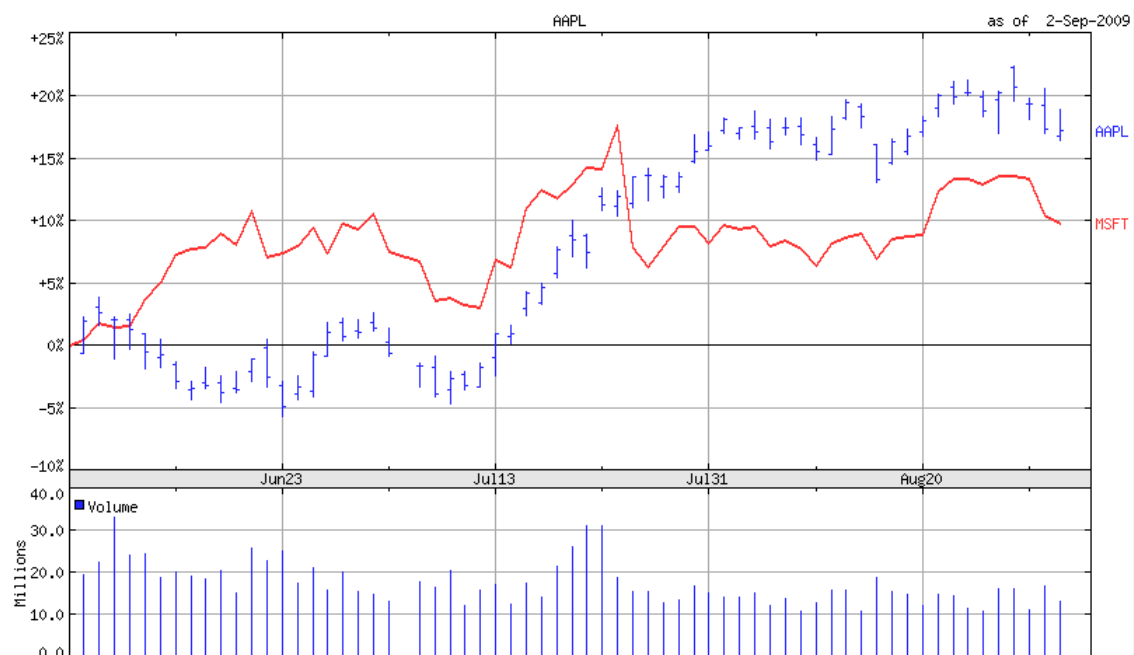
Figure 33: AAPL (blue OHLC glyphs) vs. MSFT (red line) [Yahoo, 2009]

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The latest chart from Yahoo Finance is a highly interactive technical chart. The user has the ability to compare more than two stocks and / or stock indices. A novelty which is not available for the two previous described Yahoo Finance charts.

The interactions zooming and panning are quite similar to Google Finance. The zooming function beneath the volume chart is the same as the zooming function of Google Finance. The zoom range can be adjusted by drag and drop of the sliders on the left and right side. The scroll bar at the bottom can be used to move the zoom range.

Yahoo Finance has also the ability to integrate news events as balloon symbols. When the user moves the mouse cursor over the balloon symbol, some details of the news event will be displayed via a popup. It automatically disappears when the mouse cursor leaves the area of the popup.

Figure 34: News details on demand [Yahoo, 2009]

The chart also includes an interactive legend which shows values depending on the mouse cursor position. In contrary to Google Finance are not percent changes displayed. Yahoo Finance shows the actual prices of the selected stocks.

It is debatable whether percent values or actual price values are better. A compromise would be to display both values or at least let the user decide which of the two should be displayed.

3.4 MSN Money

MSN Money [MSN, 2009] is an interactive web application for the visualization of stock market data by the Microsoft Corporation. It is a direct competitor for Google Finance and Yahoo Finance.

The application shows critical stock information such as opening, highest, lowest, closing / last price, volume and the previous closing price above the chart. Further displayed values are the absolute and percentage change.

Figure 35: Overview of MSN Money: Key values (top), line chart (middle) and several settings (bottom) [MSN, 2009]

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Figure 35 shows a screenshot of the whole web application. Key values are displayed on top. Below the key values is the stock price diagram. A line chart is shown although three other charts are available. The other available stock visualizations are the OHLC, the HLC and the candlestick chart.

The bottom half of the screenshot contains several settings, which the user can adjust according to his or her needs. Stocks or stock indices can be added for comparisons, the chart size can be changed (small, middle, large). Display of gridlines and key development events can enabled or disabled. The user can select between four chart types: line chart, candlestick chart, HLC chart and OHLC chart. The price axis can be modified to use a linear scale, a logarithmic scale, a scale with base 2 or a logarithmic scale with base 10.

The exact time range of the chart can be defined through input of the boundary dates. Some technical indicators such as dividends, splits and so on can be additionally displayed on the primary chart.

The volume information or some technical indicators such as MACD (Moving Average Convergence / Divergence), RSI (Relative Strength Index), the money flow index or the on balance volume can be displayed on an optional secondary chart beneath the main chart.

MSN Money offers a simple zoom function through a few buttons, which represent predefined time spans like 1 day, 5 days, 10 days, 1 month, 3 months, 6 months, 1 year, 3 years, 5 years, 10 years and the max years. These common zoom ranges are also available in Google Finance and YAHOO Finance.

The application provides also an interactive zoom, through the selection of a certain time period by holding the left mouse button. Figure 36 shows the visual feedback of the zoom function. The selected area is highlighted and the start and end date are displayed. After the release of the mouse button, the chart will automatically zoom in to the selected time span.

This zoom seems more intuitive and is consistent to zooming in other audio and video editing software. The user knows exactly the time range of the zoom through the display of the boundary dates. Unfortunately there is no function to zoom out. The zoom function is different to the interactive zoom function by Google Finance and Yahoo Finance. Both let the user drag two vertical bars (i.e. boundary dates) to zoom the desired time range.
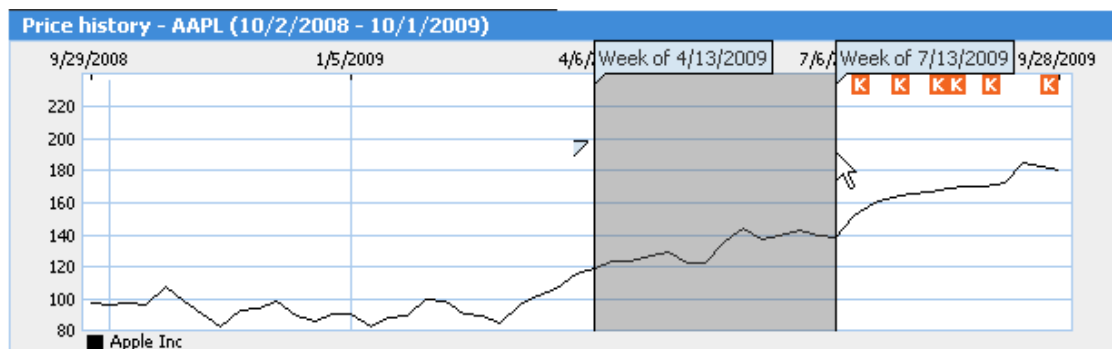

Figure 36: Selection of zoom area visualizes the boundary dates [MSN, 2009]

Figure 37 shows how MSN Finance offers details on demand via a popup containing additional information such as the date, the volume, the closing price and the color-coded absolute price change compared to the previous day. The popup window is automatically placed next to the mouse cursor. This can sometimes cause problems, because the popup window may hide parts of the chart. It could be better to use a legend in a fixed position above the chart, like in Google Finance and Yahoo Finance.
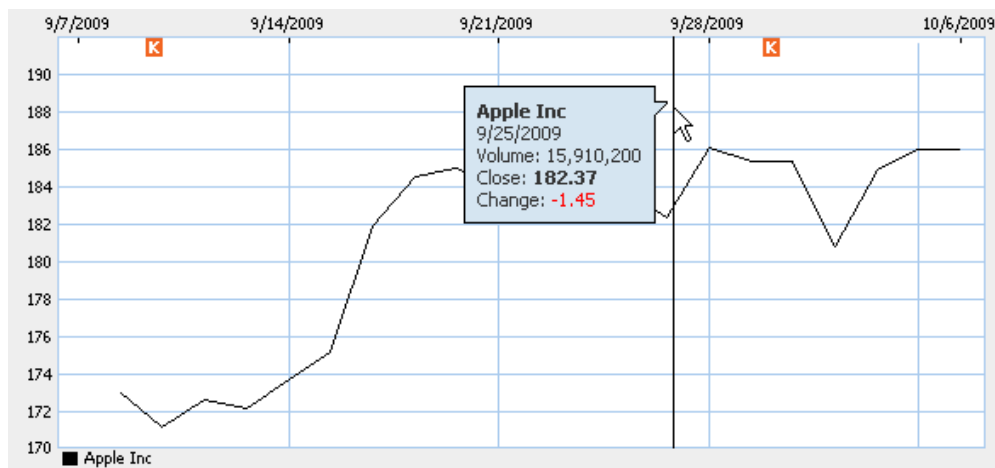
Figure 37: Details on demand via popup with additional stock information [MSN, 2009]

3.5 Finianz

The Fininaz website [Finianz, 2009] provides sparklines visualizations for important stock market indices like DAX, Dow Jones and NASDAQ.

Figure 38 displays seven stock market indices over a one year time period on the left column and over a five year time period on the right column. Each sparkline has the same height and weight available for display.

The horizontal axes are synchronized for better visual comparisons between the indices. The vertical price axes are not equal. Minimum and maximum values differ for each sparkline.

Maximum, minimum and last values are additionally displayed in numerical form. The values can be distinguished by their color. Green refers to the highest value, red refers to the lowest value and blue refers to the last value. The positions are marked by a small dot on the sparkline.

The sparklines visualizations are static and cannot be changed by the user. However this is of no concern as sparklines are not intended to be interactive visualizations.

Börsenkurse

ISIN/WKN/Ticker-Symbol: [_____] [Börsenplätze ▼] [Kurse abfragen] (Aktien-Suche)

	Kurs	Zeit & Datum	Performance	Eröffnungskurs	Tagesspanne
DAX	5728.33	09:25:00 22.09.2009	+59.68	5686.84	5686.84 - 5752.70
TECDAX	771.03	09:25:00 22.09.2009	+13.10	761.15	761.15 - 771.05
MDAX	7402.61	09:25:00 22.09.2009	+128.11	7299.20	7299.18 - 7410.50
SDAX	3465.22	09:25:00 22.09.2009	+18.33	3446.20	3441.87 - 3477.53
DJ EUROSTOXX 50	2894.95	09:25:00 22.09.2009	+22.44	2883.56	2881.56 - 2907.06
DJ STOXX 50	0.00	01:00:00 01.01.1970	N/A	0.00	0.00 - 0.00
DOW JONES	9817.02	09:40:00 22.09.2009	+38.16	9779.61	9725.88 - 9827.23
NASDAQ	2148.49	09:40:00 22.09.2009	+10.45	2150.02	2145.24 - 2150.04
NIKKEI	10370.54	03:00:00 18.09.2009	-73.26	10379.21	10292.50 - 10399.42

Kursentwicklung	1 Jahr	5 Jahre
DAX	6173.03 / 3666.41 / 5668.65	8105.69 / 3666.44 / 5668.65
TecDAX	772.94 / 405.14 / 757.93	1043.84 / 405.14 / 757.93
MDAX	7656.86 / 4163.42 / 7274.50	11377.94 / 4163.42 / 7274.50
SDAX	3847.07 / 2163.23 / 3446.89	6659.19 / 2163.23 / 3446.89
DJ EUROSTOXX 50	3207.11 / 1809.98 / 2186.79	4557.57 / 1809.98 / 2186.79
DJ STOXX 50	2761.75 / 1614.75 / 2055.03	3998.93 / 1614.75 / 2055.03
DOW JONES	11143.13 / 6547.05 / 9778.86	14164.53 / 6547.05 / 9778.86

Figure 38: Sparklines for multiple stock market indices over a 1 year time period (left column) and a 5 year time period (right column) [Finianz, 2009]

3.6 FundExplorer

An equity mutual fund is a special type of mutual fund which only consists of various stock investments. An equity mutual fund enables its investors a few advantages like shared transaction costs and a portfolio management by experts (i.e. fund managers). The diversification of stock investments does lead to lower risks.

Naturally shareholders are also interested in investing their money in multiple equity mutual funds to even further spread risks. However the visualization of such bundled sets of stock investments requires special considerations.

The FundExplorer is a unique visualization for (multiple) mutual funds. It uses a special tree map visualization for the display of the diversification of the stock investments.

"Our visualization is based on the notion of distorting the classic treemap visualization, trading proportionality of a mapped attribute for a more inclusive visualization. […] The distorted treemap (bottom) is a compromise between showing all the data elements—even those with zero value—and a classic treemap that preserves values' proportions (top)." [Csallner et al., 2003]. Figure 39 gives a schematic view of the Context Treemap.
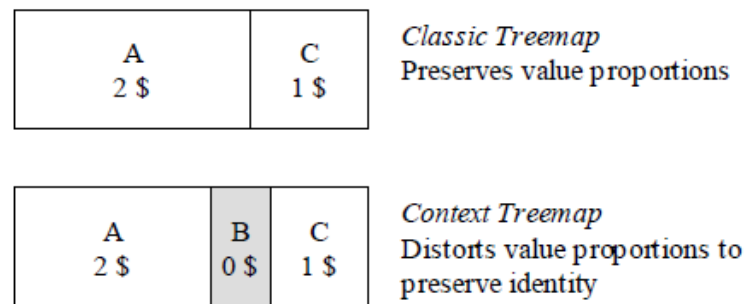
Figure 39: Classic Treemap (top) and Context Treemap (bottom) [Csallner et al., 2003]

Figure 40 is a screenshot of the FundExplorer application. The screenshot gives a good overview of the stock investments. The green-colored rectangles visualize stock investments of two equity mutual funds. One fund is represented by light green color and the other fund is represented by dark green color. The size of the green-colored rectangles is depending on the value of the stock investment.

The Context Treemap makes the selection of various fitting mutual funds much easier than before. The small gray-colored rectangles refer to the context of fund's stock investments i.e. stocks belonging to other equity mutual funds. The investor can quickly view all possible alternative stocks and mutual funds, which include these stocks. Also, overlapping stock investments between the two selected funds are quickly spotted through the comparison of location of the rectangles.

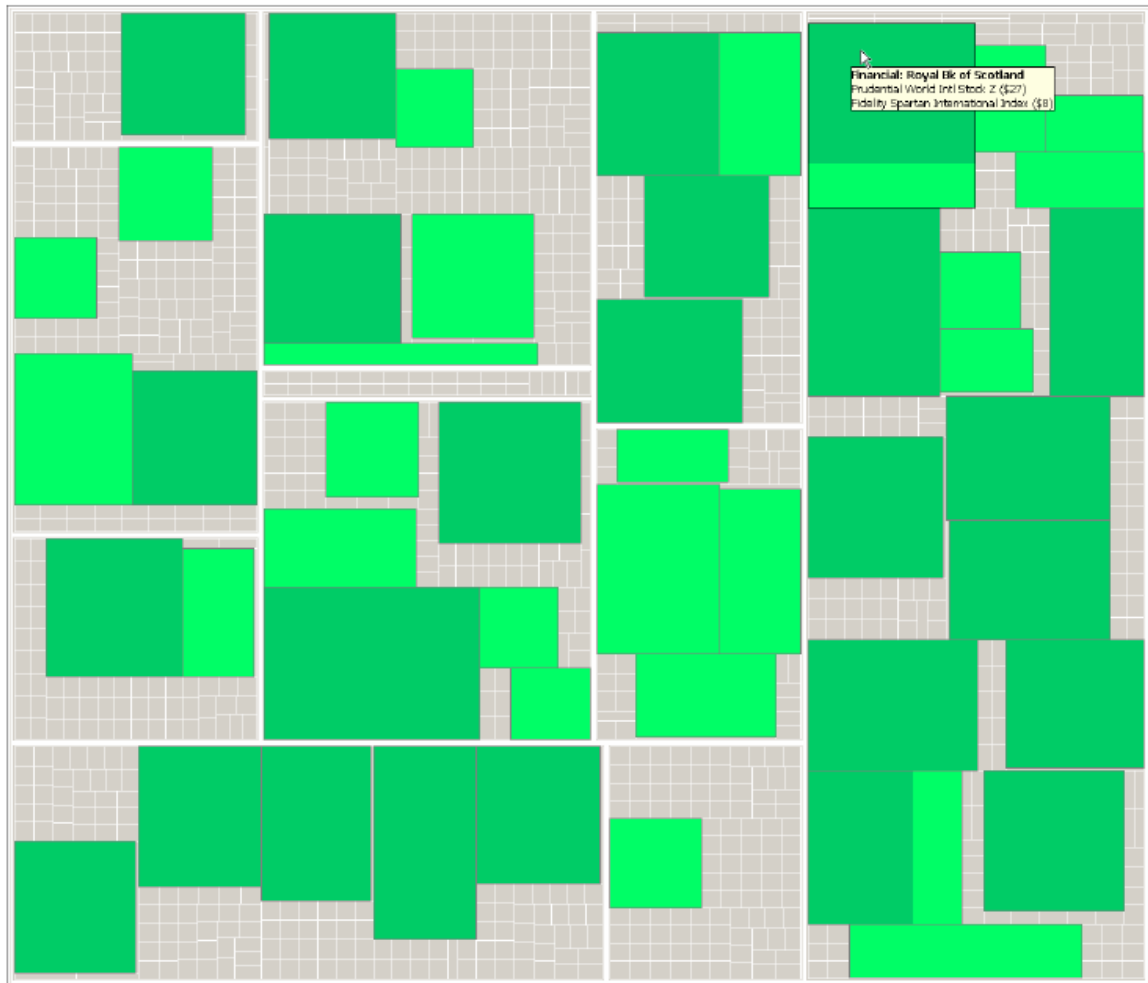**Figure 40: Visualization of two equity mutual funds and their stock investments as green colored rectangles depending on the stock investment amount [Csallner et al., 2003]**

The FundExplorer application is a special visualization for equity mutual funds to increase the diversification of the portfolio, which should reduce the overall stock investment risk.

3.7 Financial Visualizations

Financial Visualizations (abbr. FinViz) provides a lot of stock market information through the use of line charts, OHLC (Opening, Highest, Lowest & Closing prices) charts, candlestick charts and treemaps / heatmaps.

The heatmap visualization [Finviz, 2009] gives a full overview of a whole stock market in only one diagram. This visualization can encode various technical indicators such as 1 day performance, 1 week performance, P / E ratios, etc.

The detection of outliers is very easy, because only the colors have to be compared. Also correlations between stocks and / or stock sectors can be identified by comparing the colors of the stocks. A further advantage is that the overall trend (i.e. is the majority of stocks more green or red) of whole stock market index can be identified at a glance.

Figure 41 shows all stocks of the SP500 market index. The stocks are grouped by certain sectors such as technology, services, basic materials, finance, consumer goods, industrial goods, etc. Stocks are represented by single rectangles, whose size is according to the market capitalization of the stock. The colors encode the performance of one day similar to a candlestick glyph. At the bottom of the treemap is a legend which illustrates the shades of colors for +/- 0%, 1.5% and 3%. Positive values are represented by shades of green and negative values are visualized by shades of red. Each rectangle shows the symbol of the stock and the percent change of the current price to the closing price of the previous day.

Figure 41: Heatmap of all stocks of the SP 500 index [Finviz, 2009]

3.8 Further examples

IGrapher [iGrapher, 2009] is a highly interactive line chart visualization for stock market data. The web application does only show the closing prices. Other price information (high, low, open), the volume or technical indicators are missing. However the iGrapher application should be well suited for quick checks of stock price developments on mobile devices.

More professional charts for chart analysts are available from the Morningstar website [Morningstar, 2009]. The user can choose between interactive line and OHLC charts with linear or logarithmic scale. A MouseTracker function shows stock prices according to the mouse position. Zooming of data is done by a simple left click on the chart. After that, a vertical line with two arrows appears. One arrow defines the left boundary and the other

arrow defines the right boundary. After the right placement of the boundaries via drag and drop, the chart will be zoomed in according to the boundary dates.

StockCharts [StockCharts, 2009] is another website devoted to chart analysts and therefore provides also a great variety of stock charts. The user can choose between line charts, OHLC charts, candlestick charts and Point & Figure charts. Also treemap visualizations of a few market indicators are available. It also includes a performance comparison chart. This is a special line chart, which is able to compare multiple stocks based on a selected base stock. The other stocks are compared to the prices of selected base stock. Each stock is represented by the percent change between the stock and the base stock.

Figure 42: Line chart with three stocks (left) and the same stocks on a performance comparison chart with the blue stock as the base stock (right) [StockCharts, 2009]

BigCharts [BigCharts, 2009] is also more oriented to the professional analyst. Line chart, mountain chart (i.e. filled line chart), OHLC chart, candlestick chart and a dot chart are available. News events such as dividends and earnings can be visualized on the chart. Technical indicators are displayed in juxtaposition below the main chart. Up to three technical indicators can be viewed at the same time. A MouseTracker shows the values for the chart and the technical indicators according to the mouse position on the chart.

3.9 Summary

In this chapter various web applications for stock market data visualization are discussed. Many applications provide a standard set of fixed time ranges for zooming. The switching between a linear and a logarithmic scale, the selection of stocks and stock indices and display of volume and moving average are available in most applications.

Google Finance and Yahoo Finance provide many interactive techniques like the dynamic legend, which shows values of the displayed data according to the position of the mouse tracker. Another interactive technique is a time slider component which is used for interactive zooming and panning.

Most applications use line charts, OHLC charts and candlestick charts to display individual stock. Unfortunately no applications use juxtaposed OHLC charts and candlestick charts for a comparison of multiple stocks.

Only line charts are displayed in superimposition in order to compare multiple stocks. A few applications make also use of the indexing method, which can enhance the comparison to show percent changes directly. However the indexing point is always restricted to the first point in time which is displayed. The user can not set the indexing point by himself / herself.

4 User & Task Analysis

The identification of common user tasks is a significant part for the evaluation of different stock visualizations. Of course user tasks are not equally important for every user. The importance is certainly depending on the overlying goal or work scenario.

Qualitative interviews will be of great assistance in order to gain a deeper understanding of the standard work processes of domain experts. The focus of the interviews will be on the comparison of multiple stocks and / or stock market indices. For valid results should the interview partner be experts in the domain of finance applications.

Major advantages of qualitative interviews are:

- The research questions are represented in form of keywords, which will be explored. It represents more of a checklist to guide the interviewer.

- The form is open to new aspects of the research problem, which the interviewee themselves and the interviewers were not anticipating before. The qualitative interview supports the ability to learn new things about the subject.

- The interview supports a narrative approach. The interviewed person is encouraged to elaborate his / her thoughts and to give examples about their opinions. New issues about the subject can be raised during the interview.

The qualitative interview is often defined as a semi-structured interview. The questions are open formulated, which lets the interviewee a lot of freedom for the answer. This leads to more flexible interviews, where the interviewer can react on new aspects during the interview.

The interview process is problem-centered, thus the questions are formulated around the main subject(s), which is in this case the visual comparison of stock-market data. An interview guide was written, which consists of eleven questions. This guide will ensure that the main questions will be discussed.

One advantage of this interview method is that the interviewee can unrestrictedly articulate his experience and also new questions can be examined if new and interesting issues are revealed during the interview.

An important goal is to gain an overview of the most common user tasks for comparing various stock market data. A goal is to find applications which are widely used and how these applications are presenting the stock market information. Another goal is to get ideas for other important data, which could be useful for analyzing stock market data.

The complete questionnaire for the interview is included in the appendix. It contains 12 pre-defined questions which are intended to guide the interview process.

Unfortunately three participants could only be contacted by email. The interview was slightly modified for this three people. The semi-structured interview was changed to resemble a more structured interview similar to an interview form.

4.1 Qualitative Interviews

4.1.1 Participants

Six domain experts have participated in the user task analysis. Four interview partners had a university degree at the time of the interview and three were employed at the time of the interview. All persons are male.

Three participants stated to favor the investment strategy which is smaller than one year. Two chose an investment strategy between 1 and 5 years. One person selected a long term investment strategy.

Interview	Interview Type	Job title	Age	Gender	Education	Typical Investment Strategy
A	Semi-Structured	Finance Analyst	20 - 30	Male	University	> 5 years
B	Structured	Student (Informatics)	20 - 30	Male	University	< 1 year
C	Structured	Designer	40 - 50	Male	School	< 1 year
D	Structured	„Industriemeister"	30 - 40	Male	School	1 - 5 years
E	Semi-Structured	Student (Mechanical Engineering)	20 - 30	Male	University	< 1 years
F	Semi-Structured	Professor (economic mathematics)	> 50	Male	University	1 - 5 years

Table 1: Task analysis participants

4.1.2 Interview A

The first interview partner is 28 years old. He is working part time at a hedge fund Company and studying at the Technical University of Vienna.

The hedge fund company has developed a series of proprietary tools for their various finance analyses. The analyses are based on mathematical formulas and models. Additionally are line charts and bar charts generated, which are used for customer reports. However they are not used to give aid for important decision.

In his opinion the exchange rates do have an impact on import and export. He said that an increasing exchange rate can cause a price increase of the exported goods, which can easily affect the profit and strategy of a trading company.

In times of financial instability many investors he switches to precious metals and raw materials. Those have more consistent prices and have less risk of decreasing prices.

He said that the interest rate is a well-known regulation strategy to put additional money in circulation. Lower interest rates result in increasing stock investments. Stocks are an alternative to traditional savings accounts so the interest rates can shift a lot of money from one to the other alternative. But he also thinks that there are many other finance investments besides stocks. He believes that there exists no general valid rules between dependencies of stocks.

4.1.3   Interview B

The second domain expert is 20 years old and studying at a German University. He uses the software WISO Börse 2009 to handle stock trading. In most cases he sells stock within one year after the purchase.

He uses line charts and candlestick charts to monitor stock price movements. He said that line charts are needed to compare stocks and to get a basic overview of the price movement. Afterwards he uses candlestick charts to gain more details about the price movement.

He does not compare stock prices by using candlestick charts, because the software application WISO Börse does only compare stocks by using line charts. He watches the stocks not for long-term periods (more than10 years) and also for short-term periods (few hours). The period depends on the investment strategy he wants to use.

The visualizations of the stock price development is very helpful to him. He uses it to analyze and identify trends and to decide between stocks. Interaction techniques like zooming, panning and filtering are important for him and give him a better understanding of the data.

The correlations between stocks are not important to him. Also he does not consider any other international or national economic data for his analysis.

4.1.4   Interview C

The third person is over 40 years old and a private trader. He prefers to use the finance web site OnVista [OnVista, 2009] to analyze stocks within the time period of 5 to 10 years. He favors the combination of line charts and candlestick charts to visually analyze the stock price development. The display of the (absolute and percent) stock price values is the most important information for him. He is not interested in other technical indicators like Moving Average.

One main disadvantage for the participant is the quite limited zoom function of OnVista. He can not define by himself the time range. He can only select between one day, one month, three months, six months, one year, three years, five years and ten years. The visua-

lization lacks the ability to change the displayed time range more freely. Possible solutions would be a free input of the start and end date and the integration of a mouse wheel zoom function.

He said that another handicap of OnVista is that the legend does not show the stock price depending on the current position of the mouse cursor on the chart.

4.1.5 Interview D

The fourth person is more than 30 years old. He trades stocks for his own gain since 23 years. He uses a mixture of different software and web applications such as Fondsweb [Fondsweb, 2009], Cominvest [Cominvest, 2009] and Cortal Consors [Cortal, 2009].

He uses regularly line charts and pie charts. Line charts are generally important to him for the display of stock prices, while pie charts are good to visualize the percent distribution of stocks within hedge funds. Charts are important to him, because they can show the price trend much better than any numerical data. He monitors stocks prices of long-, middle- and short time periods. He also uses the Markowitz model [Markowitz, 1952] to balance the expected return and risk of his portfolio.

In his opinion the influence between stocks should not be underestimated. He thinks that when a lot of stock prices fall then bonds will rise. He stated further that at the same time consumption, consumer goods and certain types of raw materials are increasing.

He thinks that economic data like GDP, interest rates and important news events can also influence stock prices. The major events such as the Olympic Games and other World Cup or European Championships give the local area certain positive economic effects. He argued that this can indirectly affect the development of relevant stock prices through stimulation of the economy.

4.1.6 Interview E

The fifth domain expert is a 27 year old student from the Technical University of Vienna. He is trading stocks for more than six years. For him it is an opportunity to get additional money in his free time besides his study.

He changes his investment strategy depending on the state of the stock markets. He often uses a time interval between one day and one year, which is also depending on the situation. He said that in times of a financial crisis, it can be profitable to use a short-term investment strategy.

The technical analysis is important to him before he invests in a particular stock. At first he compares the stock indices to identify which area does have a good general trend then he compares the charts of individual stocks. The technical analysis is not enough for him to make a decision. Additionally he analyzes the fundamental data of the companies to check the health of these companies. He also likes read news about the companies to get more information. He said that big news events can have a great influence on the future stock prices of companies.

His prefers line charts and candlestick charts. He said that line charts are great to identify price movement in real time within one day. So he uses them for short-term investments. He believes that candlestick charts are well suited to analyze the daily or monthly price and volume fluctuations.

He thought that the relationship between stock price and volume is very important. The price change should correspond to the volume change. If the volume increases, the demand is higher than supply. This will most likely increase the stock price. Conversely, if the volume goes down, demand is lower than supply. This might cause a decline of the stock price. It is his opinion that when the price changes and the volume does not change appropriately within a given time it is considered best to ignore this stock.

Besides the stock price and volume he also observes the moving average to find the trend of the average values.

He said that if the stocks prices have similar price movements, then he will compare the stock sectors of the stocks. If he thinks that a stock sector is not healthy enough, he will not invest in the stocks. Then he will use fundamental data like profit, dividends, revenue, earnings per share, P/E ratio (price-to earnings ratio) to check the health of the companies. The earnings per share relates to the return when he has invested in the stock.

An annoying problem is that his software does not provide the possibility of a comparison of candlestick charts for multiple stocks. But it is essential for him to compare the candlestick charts of many stocks against each other. His workaround is to take screenshots of each candlestick chart and then to use image editing software to manually compare the charts.

He thinks that stocks can influence each other, if the companies of these stocks have investment relationships. For example, many banks like to give loans to real estate companies. If the stock prices of the estate companies increases, the stock prices of the banks will also rise. The interest rate can have influence on the railway transport area and international trade.

International and national economic data such as GDP growth rates, CPI growth rates, interest rates, exchange rates, inflation rates, energy prices, and the financial support from government can have a great impact on stock prices according to him. Unfortunately most software does not provide this information, so he has to search the data by himself.

Interactive visualization techniques are very helpful to him. An interactive zoom function can be used to adjust the displayed time period without the disturbance of reloading the whole chart. He considers dynamic legends to be useful, which display values depending on the mouse pointer position,.

4.1.7 Interview F

The last interview partner is a professor of mathematical economics from the Technical University of Vienna. He likes to compare multiple stocks with mathematical methods.

He said that the main goal of stock comparisons for him is to find a set of stocks, which can minimize the estimated risk by spreading the investment into a diverse amount of stocks. He does this by calculating the correlation of a stock against a relevant stock market index. Capital Asset Pricing Model (CAPM) is a effective model for identifying better than average stocks and also to distinguish between stocks. CAPM calculates the sensitivity of the asset returns in relation to market returns.

He analyzes stocks mostly with the previous described mathematical calculations. For graphical comparisons he uses line charts.

The range of the displayed data is dependent on the investment strategy for him. Most of the time only real time data and historic data of the last few days are required for speculative investments. He said that for long-term investments are greater time spans such as 5 or 10 years important.

A fundamental analysis can provide valuable information, which can speed up the decision process. A reasonable way to identify good stocks is by comparison against a proper stock market index like Dow Jones, S&P 500 or NASDAQ. The selection of the right stock market index is the key to a winning comparison. Dow Jones is a good indicator for industrial companies. S&P 500 is suited for most general companies and NASDAQ is suited for technical companies.

In his opinion the volume is of importance for the determination of the "real price" behind the stock price. A low volume value may indicate that the price is not representative and thus strong differences between the stock price and the "real price" exist.

Some important indicators are profit, P/E ratio, company news, production index, output and economic data like inflation, foreign trade deficit, employment, unemployment rate.

In the case of a merger of two corporations the price of the shares of the acquired company usually increases he said. Stocks within an industrial area can often correlate because they belong to the same market. He added that stocks of rivals are influencing each other. Stocks of companies that compete in oligopoly structures like banks or car manufacturers are also often correlated.

He said that linear and logarithmic scales show different aspects of the data. A linear scale is best to display absolute values respectively absolute differences. A logarithmic scale visually represents percent changes, which is useful for many comparisons.

He argued that there is a general assumption about the market model demand that all needed information is included in the price. Consequently the price is changing according to all relevant information. However he added that the market is also influenced by irrational behavior. Irrational behavior cannot be explained and therefore cannot be predicted. He also thinks that company news can have a big influence on the stock price.

4.2 User Task Taxonomy

The acquisition of suitable and relevant user tasks into a well-defined set is of great importance for design, evaluation and selection processes of visualizations because of the following reasons.

A well-defined set of user tasks establishes the most common requirements of the users. Designers can focus on the tasks and analyze the needs of the users.

Visualizations can be evaluated and compared in a more scientific approach. The definition of user tasks makes tests reproducible. Test can be repeated and gain validity by repeated accordance of test results.

The first section 4.2.1 will begin with the exploration of the well-thought-out user task taxonomy by Natalia and Gennady Andrienko [Andrienko & Andrienko, 2006]. The taxonomy gives a good overview of common user tasks which cover all relevant applications for visual comparison of time series.

The second section 4.2.2 provides some of the results of the conducted user task analysis from the last chapter User & Task Analysis. Results concerning the comparison tasks and the required data will be presented.

The information of this chapter builds the base task set for a quantitative evaluation of three visualization types of the prototype. A comparative study of juxtaposed and superimposed line charts against indexing chart is described in [Kainz, 2009].

The following task taxonomy is taken from the book "Exploratory Analysis of Spatial and Temporal Data - A Systematic Approach" [Andrienko & Andrienko, 2006]. However the main thoughts behind the taxonomy are based on the work of Jacques Bertin in [Bertin, 1983].

The user task taxonomy distinguishes between the two classes of elementary tasks and synoptic tasks. Elementary tasks put emphasis on single elements of the reference set. This concept is similar to the elementary reading level by Bertin.

Synoptic tasks focus on partial or whole set of elements of the reference set. These tasks correspond to the intermediate and overall reading levels by Bertin. The differences between the two reading levels are rather marginal, so they are placed in the same user task taxonomy class.

Natalia and Gennady Andrienko state that synoptic tasks are more important, because they reveal more information about the data. The identification and determination of trends, correlations and connections are possible outcomes from synoptic tasks, which make synoptic tasks more valuable.

"Synoptic tasks involve reference (sub)sets, behaviours, and relations between (sub)sets or between behaviours.[…] Elementary tasks play a marginal role in exploratory data analysis, as compared with synoptic tasks."[Andrienko & Andrienko, 2006]

4.2.1 Elementary Tasks

Elementary task can be simply represented by the general formula:

$$f(x) = y$$

where x denotes the independent variable such as the time or date of a stock. This can be described for several variables or referrers by following formula:

$$f(x_1, x_2, ..., x_m) = y$$

Some of the variables can be constraints of the task and some can be considered as targets of the task. The term targets stands for the unknown information, which needs to be found out.

There are three elementary task classes defined: lookup tasks, comparison tasks and relation-seeking tasks. Table 2 gives examples for each subcategory for every of the three elementary task classes.

Elementary Task Class	Subcategories	Example
Lookup	Direct lookup	On a given date what was the price of stock X?
	Inverse lookup	For a given price, on what date(s) was it attained?
Comparison	Direct comparison	On a given date, did the stock price exceed € 1000?
	Inverse comparison	Did the stock price reach €1000 before or after a given date?
Relation-seeking	-	On what date(s) did the stock price exceed the price attained on a given date?

Table 2: Overview of elementary task classes and examples from [Andrienko & Andrienko, 2006]

Lookup tasks are further divided into direct and inverse lookup tasks. For a given value of a component of the function a value of another certain component has to be found out. Direct lookup tasks require the value of y for a specific x value. Inverse lookup tasks define a specific y value and the right x values have to be found out.

Each comparison task builds up on direct or inverse lookup task. For this reason comparison tasks are divided into direct and inverse comparison tasks. The main objective of these tasks is to identify relations between characteristics or referrers.

The objective of relation-seeking tasks is to find pre-defined relations between elements. These tasks are usually consisting of three basic operations. First a direct lookup has to be

made to find characteristics of the desired elements. The second operation is to match characteristics of the available elements according to the pre-defined relation. Third an inverse lookup is has to be conducted to identify the corresponding elements for the given relation.

4.2.2 Synoptic Tasks

The term synoptic is derived from the term synopsis which can be seen as a more general view or a summary of the whole object. Synoptic task can be represented by the following general formula:

$$\beta(f(x) \mid x \in R)$$

where β denotes the behavior, x denotes the independent variable from the reference set R. Figure 43 shows a better understandable graphical illustration of a synoptic task.

The four elements of the reference set R on the left side form a configuration (dashed lines) through a defined set of relations between the reference elements. This could be in the simplest case a chronological sequence of days for time series data.

The data function f assigns characteristics to each reference element. The characteristic elements form a new configuration (dotted lines) based on the relations of the reference elements and the data function. The new dotted configuration is called the behavior or β in the general formula for synoptic tasks above.
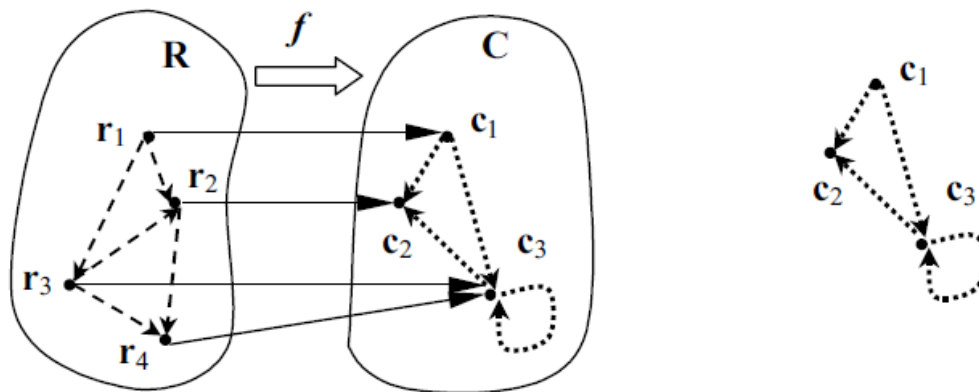

Figure 43: Graphical illustration of the behaviour (dotted lines) for a given set of reference elements and corresponding characteristics [Andrienko & Andrienko, 2006]

The three defined synoptic task classes from the task taxonomy are pattern identification, behavior (pattern) comparison and relation-seeking. Table 3 gives examples for each sub-category of every synoptic task class.

Synoptic Task Class	Subcategories	Example
Pattern identification	Behaviour characterization (pattern definition)	During a given time interval, what was the trend of the time interval?
	Pattern search	Find time intervals in which stock price increased.
Behaviour (pattern) comparison	Direct comparison	Did the stock price increase during a given time interval?
	Inverse comparison	How is a decreasing trend in the stock price related to the period of the summer vacation?
Relation-seeking	-	In what time interval was the trend in the stock opposite to that on the given interval?

Table 3: Overview of synoptic task classes and examples from [Andrienko & Andrienko, 2006]

The term pattern refers to a *"[…] construct reflecting essential features of a behaviour in a parsimonious manner, i.e. in a substantially shorter and simpler way than specifying every reference and the corresponding characteristics. The construct may be a description in some language (natural, formal, or graphical) or a mental image of the behaviour."*[Andrienko & Andrienko, 2006]

The relationship between behaviour and pattern can be understood as follows. The pattern is a (subjective) interpretation of the mathematical defined behavior. A task involving patterns may have different results for different observers, because of the subjective interpretation.

The pattern identification task class is divided into two subcategories. The aim of the first subcategory behaviour characterization tasks is to define the pattern for a given set of reference elements. The other subcategory is called pattern search tasks. This category is similar to inverse lookup tasks. A specific pattern is given and the user has to find matching subsets of reference elements.

The behaviour (pattern) comparison task class is divided into direct and inverse subcategories, which are similar to elementary comparison tasks. Both categories deal with relations between behaviours. Direct comparison tasks determine the relations between a specific pattern and patterns corresponding to a given set of reference elements. The goal of inverse comparison tasks is to determine relations between sets of reference elements corresponding to specific patterns.

The objective of relation-seeking synoptic tasks is to find specific relations between configurations of characteristics (or behaviours) and corresponding sets of reference elements.

4.3 User & Task Analysis Results

Six domain experts took part in the user & task analysis. The results and the following implications should not be considered to be generally valid for all stock market analysts because the sample consisting of six persons is probably not representative. However the results should give a simplified perspective of possible demands and requirements.

4.3.1 Task types

Three task types for stock analysis have been extracted from the interviews. All three task types are parts of the technical analysis. They are considered to be important and commonly used by our participants of the user & task analysis.

The first task type for visual analyses of stocks is to analyze the movement of the price against other similar stock prices. Trends and correlations between stocks are the main goal of these tasks. Depending on the user and the investment strategy a line chart, bar chart or candlestick chart is used. This task type requires a comparison of homogeneous data.

The second task type is the comparison of stock price with important and relevant stock indices. The user can determine whether the stock price is higher than the average or not. Stock indices are the key parts to detect any general trends of the corresponding sector. An oversimplified view of the calculation may give the idea that all indices are based on the prices of the selected stocks. The value ranges of stocks and stock indices are usually too far apart, which makes naive comparisons impracticable. The task type is therefore related to comparisons of heterogeneous data.

The third task type is also related to the comparison of heterogeneous data. This task type compares stocks with other financial and economic data such as inflation rate or exchange rates. The units of the involved data series are in most cases not equal. The data for this task type is strongly dependent on factors like the user, investment strategy, stock and stock segment, economy.

4.3.2 Relevant Data

The interviews give support that the desired investment strategy has influence on the required data for the comparison tasks.

If the investor favors short-term investment, where stocks are sold within 1 year after the purchase, real-time stock prices and volume information are the most valuable information. Stocks are often visualized by OHLC (Opening, Highest, Lowest & Closing prices) and candlestick charts, because these allow opening, highest, lowest and closing prices to be viewed. As a general rule can be assumed that the shorter the investment plan is, the more important real time prices become.

Middle-term investors (< 5 year investment) and long-term investors (> 5 years investment) use much more information in addition to stock prices and volume information. Table 4 gives a summary of the most popular stock market indices and the related stocks.

Comparisons of the given stock against other alternative stocks or against stock indices are often used to identify relative trends.

Stock index	Based on stock prices of
Dow Jones Industrial Average (DJIA)	30 most largest and widely held companies from US only
NASDAQ Composite	Over 3000 companies from US and non-US
S&P 500	500 largest market-capitalized companies from US only
DAX	30 major companies from Germany only

Table 4: Popular stock market indices and the considered stocks

The moving average can help to smooth out the stock price development. The trend is better visible because small outliners are removed.

The importance of news related to the company should not be underestimated. However the delay between the news event and the influence on the stock is unknown and the size of the impact can only be vaguely estimated.

Sometimes it can be useful to gain more knowledge about the whole economy. International and national economic data include GDP growth rates, CPI growth rates, interest rates, exchange rates, inflation rates, etc.

Fundamental data can give deeper insight into the health of the company. This data includes profit, dividend, revenue, earning per share, P/E ratio (price-to-earnings ratio).

4.4 Summary

Four of the six domain experts are using regularly some kind of stock visualizations to enhance their stock price analysis.

The interview partners can be roughly divided into two groups. The first group is consisting of professional analysts and the second group is consisting of private finance analysts. While members of the first group rely heavily on mathematical models private traders use frequently visualizations like the line chart for their analyses. Professional analysts often use charts to visualize certain trends for their customers.

Professional analysts rely strongly on mathematical models. This is not surprising because important decisions in precarious financial situations should not be influenced by human perception and beliefs. Mathematical models are a must to reduce all sorts of errors which are introduced by humans.

However interactive visualization techniques can enhance certain tasks. Zooming and panning can speed up the viewing process. The user can better imagine the "shape" of the data. Data trends are much more comprehensible via graphical representations.

Stock market visualizations provide a broad insight into a set of the involved stocks at once. It allows a summarization and determination of general trends for certain sectors through induction. Price changes can be encoded by using different colors. Positive values are displayed by green color and negative price changes can be displayed by red color. The values can be assigned to certain value ranges through certain predetermined color intensity values. Stocks are furthermore classified into stock sectors through arranging them in hierarchical structures. This makes the identification of correlations of price changes of various stocks through comparing the colors. The last chapter provided some examples such as Fund Explorer or Finviz.

Stock market data can be easier communicated through visualizations. Stock charts enable the user to understand the data faster than by just looking on a sequence of numbers. Stock charts do also provide an easier method to spot trends within the price development.

Private and casual traders do not want to miss stock charts as important part of their analyses because they provide information without difficulty and do not require a lot of mathematical background knowledge.

The graphical comparison method of superimposition is limited in most cases. The stock price is often compared with a popular stock market index or a technical indicator like the Moving Average. Superimposition of multiple stocks is constricted to line charts, which makes sense because other visualization methods do not support superimposition properly. Especially Candlestick charts and OHLC (Opening, Highest, Lowest & Closing prices) charts have disadvantages.

There is no general accepted rule about correlations between stocks, stock market indices and other economic data. The effect of financial and economic data can be dependent on the particular industrial sector, to which the stock belongs. Companies within the same sector may share similar price development. For example the companies in the food sector usually do not have price developments with high volatility. Other sectors like the car sector might react different in a market depression. People cannot resist buying food, but they can wait before buying a new car.

It is up to the individual investor to create assumptions for correlations between stock market data and other economic indicators. A good solution would be when a software application offers a broad set of technical indicators and other economic data like GDP.

The selection of the right user tasks is of great importance. The user tasks play an important role in design, evaluation and selection of visualizations.

The described user task taxonomy is based on mathematical thoughts and delivers a systematic view on user tasks. The taxonomy is divided into elementary and synoptic user tasks. Because of the systematic view a broad scope of possible user tasks can be covered.

Three task types are formulated based on the propositions of the participants from the user & task analysis. The first type compares a stock against other relevant stocks. The second type deals with comparisons of the stock against relevant stock indices. The third type is concerned with comparisons of the stock against other financial and economic data such as interest rates and exchange rates. All three types use technical data of the stock and do not take fundamental data into account. The task taxonomy and the task types together form a set of commonly used tasks for time series data.

However comparisons of technical data are not necessarily the best way to determine the chances and risks of a particular stock. Many users like to compare fundamental data of the company to check out the health of the company. Fundamental data are more like indicators for the company in the real economy. Bad values of fundamental data can easily lead to low stock prices, as the confidence of the investors may be decrease in the future.

The type of needed information is dependent on the investment strategy. Short-term investors want as much information about the stock price as possible. Opening, highest, lowest & closing price and volume are the major information pieces. Real time stock prices are also getting more important the shorter the investment strategy is.

Middle-term and long-term investors include more information about the company and the stock market. The development of the price trend is more important than current stock prices. Moving average, stock market indices and fundamental data are valuable indicators for a trend analysis.

5 Prototype: Requirements and Design

The goal of the prototype is to assist a quantitative research about common stock market data visualizations and comparison methods. The goal is to evaluate speed and correctness of the three comparison methods juxtaposition, superimposition and indexing.

Typical user tasks are the identification of stock price trends and comparisons of multiple stock prices. The focus of the tasks is to analyze homogeneous data.

The prototype application was written in the programming language Java. The language is object-oriented and provides many standard libraries. Many third party libraries are also available.

Java is interpreted by a Java Virtual Machine, which results to a broad portability of the application to all major platforms and computer architectures. The prototype application can be used on all major platforms such as Windows, Mac and Linux distributions.

The three common stock visualizations line chart, OHLC (Opening, Highest, Lowest & Closing prices) chart and candlestick chart were written using the free third party library JFreeChart [JFreeChart, 2009].

For evaluation purposes the line chart (comparison by juxtaposition, by superimposition and with the indexing method) was additionally written with the help of the third party visualization framework Prefuse [Prefuse, 2009]. Prefuse is an extremely powerful framework for interactive information visualizations.

5.1 Requirements

The requirements of the prototype are partly derived from state of the art stock market visualizations (chapter 2 State of the Art: Stock Market Visualizations and chapter 3 State of the Art: Web Applications) and partly from the user task analysis (chapter 4 User & Task Analysis).

5.1.1 Functional Requirements

The prototype application has to include the most common stock market visualizations such as line chart, OHLC chart and candlestick chart. Switching between the chart types should be fast and intuitive.

The available data should include stocks (price and volume), important stock market indices and other relevant economic data. The data should be available for the time period of 2004 to 2008.

Stocks have to provide daily values for the time period of the following information:

- Opening price
- Highest price
- Lowest price

- Closing price

- Volume (only stocks)

The same information is provided for stock market indices with the exclusion of volume information.

An important use case is the comparison of multiple stock market data and other economic data. Line charts should be compared by juxtaposition or superimposition. Another comparison method is by using the indexing method with a superimposed line chart. Other visualization types such as OHLC and candlestick charts can only be compared by juxtaposition.

The selection of the displayed data should be always changeable by the user with immediate effect. The scale of the price axis should be switchable between linear scale and logarithmic.

The volume information has to be displayed below the main chart and the moving average can be displayed in the same diagram of price movement. The moving average should be calculated at runtime. The calculated values will not be stored. This reduces space and adds flexibility, because the moving average could take parameters (for example the amount of days) as input.

With the availability of modern computers visualizations are not static anymore. The users can interact with the visualization to alter the display of the data or the data itself. The major advantage is an enhanced exploration of the data.

Ben Shneiderman discusses in [Shneiderman, 1996] seven important direct manipulation approaches (user interactions) for dynamic visualizations. The interaction tasks are defined at a high level of abstraction. Adaptations of the tasks in order to be usable may be needed. The following text lists the seven interaction tasks:

1. Overview: A total view of the entire data set.

2. Zoom: Zoom in or out depending on the interest.

3. Filter: Remove unneeded data items.

4. Details-on-demand: Only show details when the user wishes to see it.

5. Relate: Display relationships between the data.

6. History: Enable undo, replay, and progressive refinement actions.

7. Extract: Enable extraction of data and of the query parameters.

It is not intended to provide all of the above mentioned interaction tasks for every visualization. The list should be considered when designing the visualization's interaction tasks. The usefulness of the tasks is dependent on the visualized data, the visualization itself and the user tasks.

The prototype should include a zoom function for predefined zoom ranges (5 days, 2 weeks, 1 month, 3 months, 6 months, 1 year, 2 years and 5 years). The user can filter whole data sets by clicking on the associated checkbox on the window. Details on demand such as date and value(s) are displayed via a popup, when the mouse cursor hovers over a data point.

The prototype should contain an evaluation modus for testing the efficiency. The evaluation modus will contain the related questions that the test person will answer.

The legend should display values of the enabled stock market data depending on the mouse cursor position.

5.1.2 Technical Requirements

The prototype application should not require access to internet. The stock market and other economic data have to be stored locally inside the application. CSV-files are common practice for storing large amounts of data. The stock market data from 2004 to 2009 was taken from the Yahoo Finance web service [Yahoo, 2009].

The technical indicator moving average is not stored. The values are calculated by the prototype when needed.

Economic data of labor like CPI, PPI and unemployment rate are extracted from the US Bureau of Labor Statistics [BLS, 2009]. US interest rates are taken from the Organisation for Economic Co-operation and Development [OECD, 2009].

5.2 Design

The design of the prototype is intended to be consistent to a standard look and feel. The default size of the windows is 900 x 800 pixels (width x height). The window can be adjusted and maximized to fit the user's needs.

The user interface of the application is divided into seven areas. Figure 44 is a screenshot of the prototype, where the following areas are marked.

1. Tab bar: The user can switch between the charts by clicking on the tab of the desired visualization type. This makes switching fast and shows all possible alternative charts.

2. Chart drawing area: The space is reserved for the drawing of the chart.

3. Indexing point: This area is only available when the indexing chart is active. The indexing point can be set to first, last or a given date. It is also possible to define the indexing value based on the mean value.

4. Chart Settings: The user can choose between the usage of a linear scale or a logarithmic scale. The zoom function allows switching of the displayed time period according to pre-defined values like 1 month, 3 months, 6 months, etc.

5. Stock Selection: The user can select among the stocks. Volume information and the 20-days moving average can also be added.

6. Indicator Selection: Four major stock indices (Dow Jones Industrial Average, NAS-DAQ, DAX and SP500) and four economic indicators (Consumer Price Index, Producer Price Index, interest rate and unemployment rate) of the USA are available.

7. Evaluation Mode: The button starts the evaluation mode. This mode is used for quantitative research. More information is given in section 6.4 Related Comparison Study.
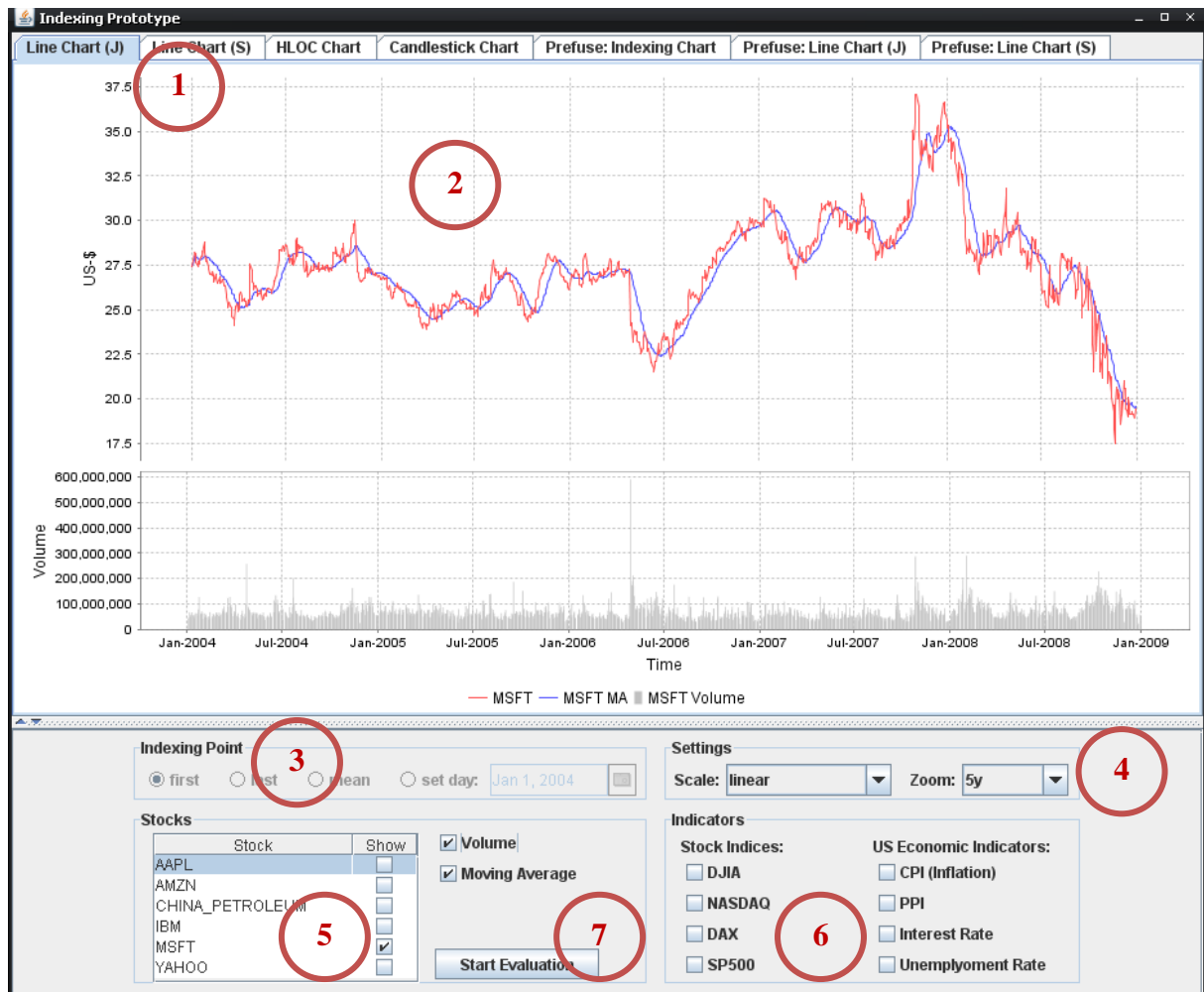

Figure 44: Prototype application displaying one stock with volume and moving average indicator

The tab bar of the prototype includes the following visualization types:
- Juxtaposed line chart
- Superimposed line chart
- OHLC chart
- Candlestick chart
- Indexing chart (Superimposed line chart with indexing method)
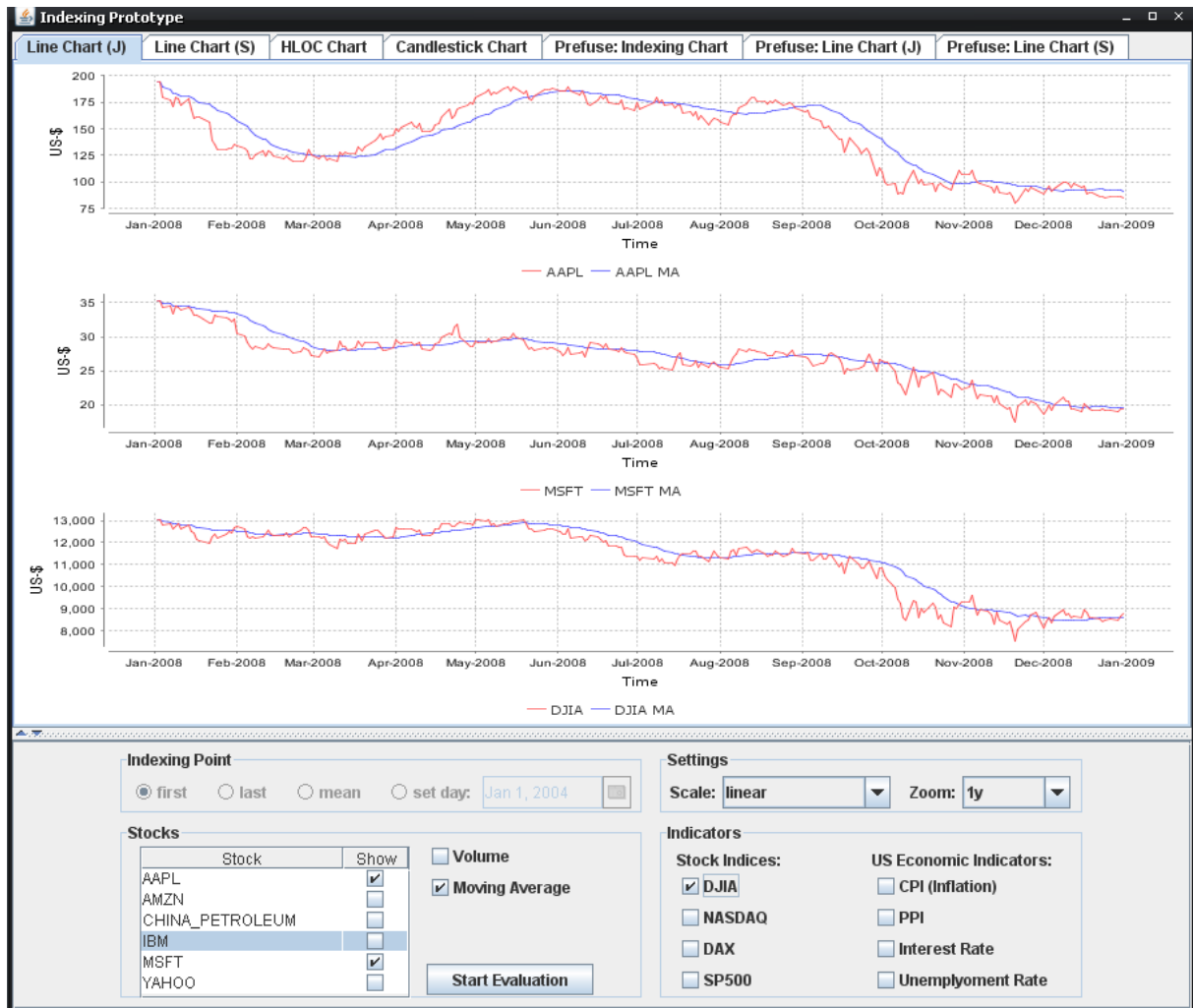
Figure 45: Juxtaposition of three line charts (two stocks and one stock index)

Figure 45 shows three juxtaposed line charts of two stocks (AAPL on top and MSFT in the middle) and the stock index Dow Jones Industrial Average (DJIA). Each stock and the stock index are plotted separately. Each diagram contains additionally a 20-days moving average.

The value ranges of the price axes are adjusted in accordance to the displayed prices. The individual trend and price fluctuations are clearly visible. However, comparisons have to be carefully conducted and the different value ranges have to be kept in mind.
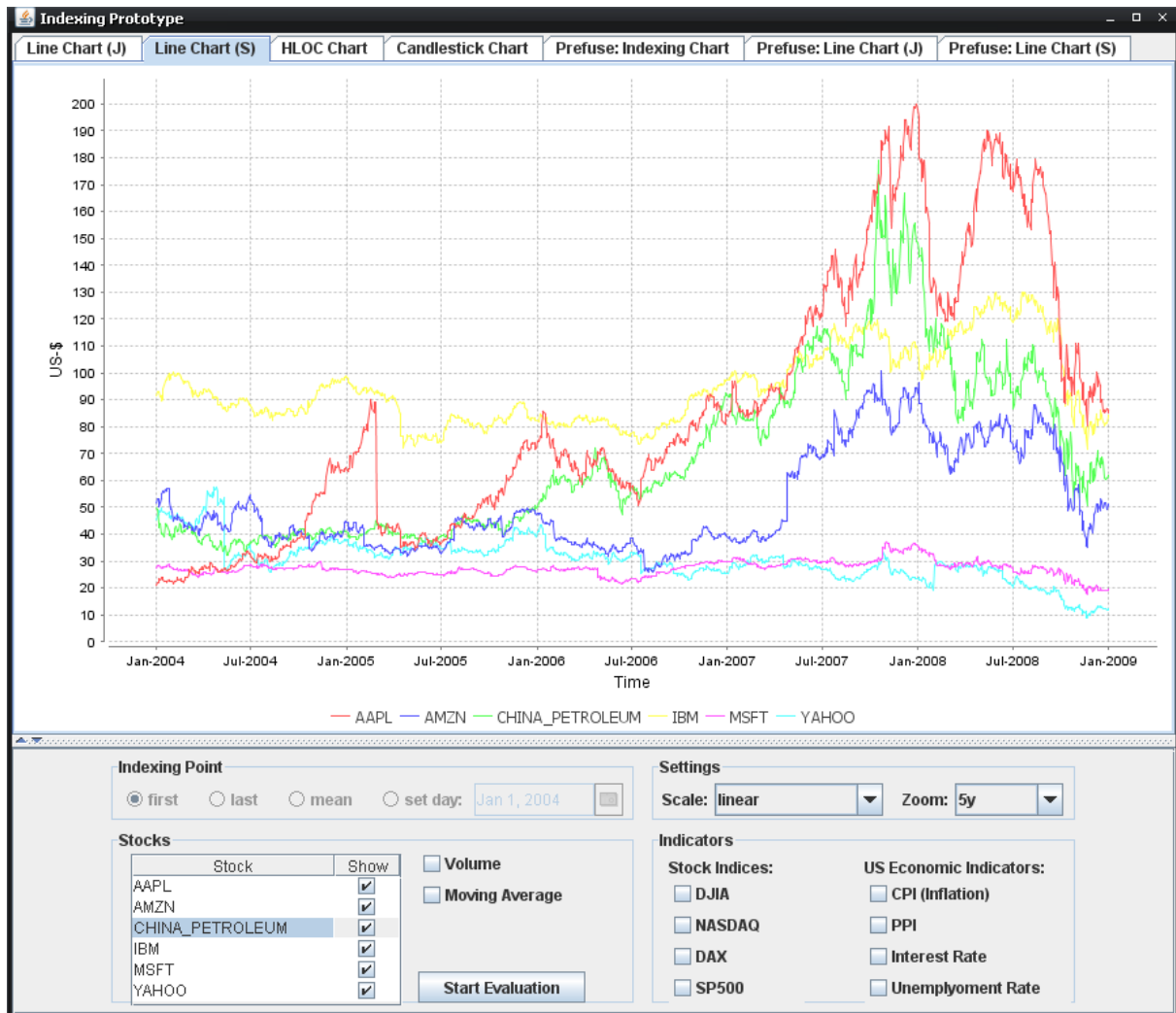
Figure 46: Superimposition of six stocks with a line chart visualization

Figure 46 depicts a superimposed line chart of six stocks. All stocks use the same time axis and price axis. This makes a comparison of the stock price development easier. By looking at the chart, the following relations can be figured out:

- The stock price of IBM (yellow) is always higher than the price of MSFT (magenta) and YAHOO (cyan).

- The stock price of AAPL (red) is very volatile. From 2004 to 2007 AAPL had enlarged from 20$ to 200$ which is a 180$ rise. Within a few months AAPL suddenly declined 80$. In the second half of the year 2008 AAPL's stock price decreased around 95$.

The superimposed line chart can effectively present the solutions to the questions:

- Which stock has the higher price for a given time or time period?

- Which stock is more stable in a given time period?

Figure 46 shows a direct comparison of six stocks. Through the use of different colors it is possible to distinguish between the stocks without many problems.

The next chart is the OHLC (Opening, Highest, Lowest & Closing prices) chart. OHLC charts give the user more information about the stock price development than line charts. Additional values are opening price, highest price and lowest price for a given day.
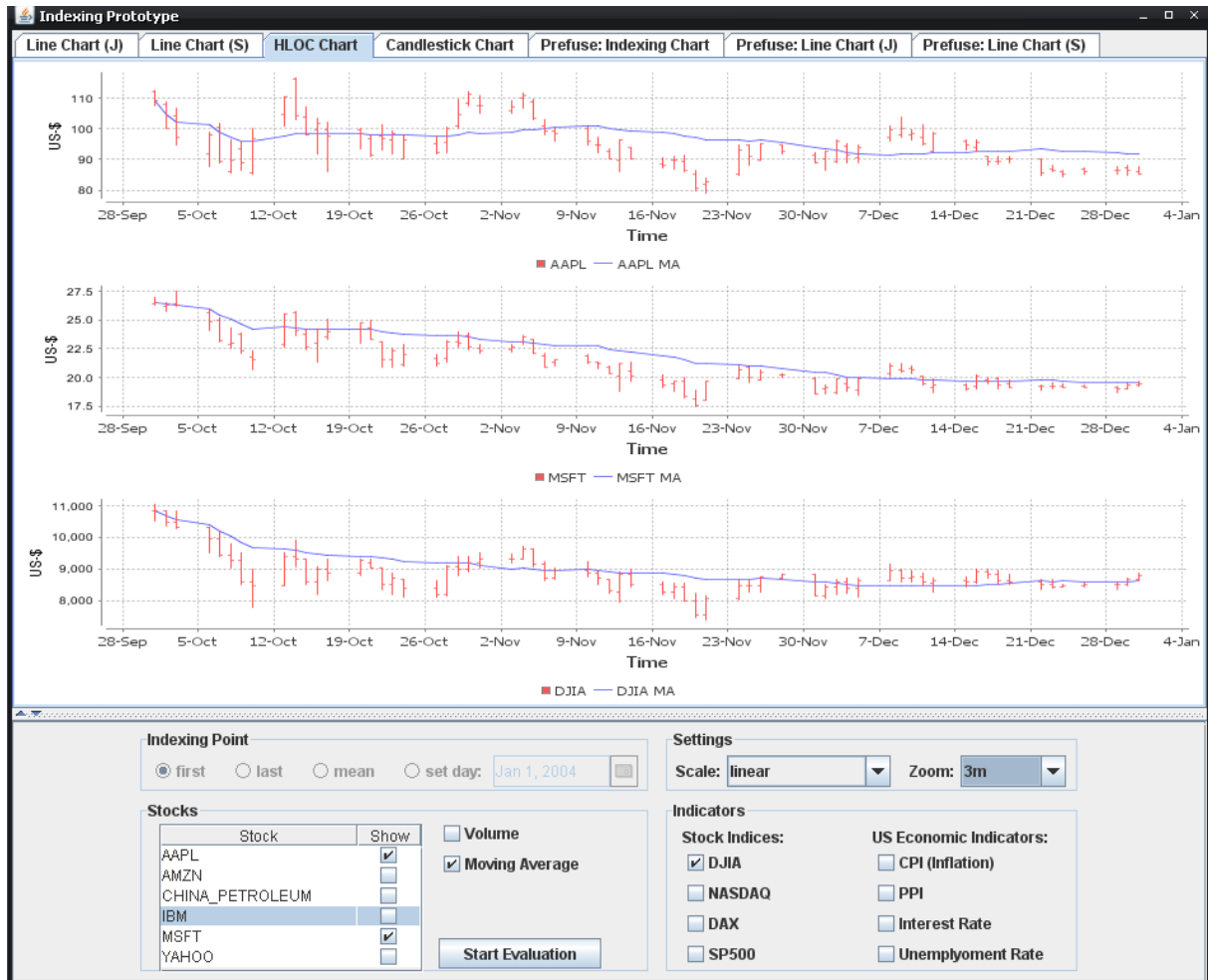

Figure 47: Juxtaposition of three OHLC charts

Figure 47 shows three juxtaposed OHLC charts of two stocks and one stock market index. All charts additionally display the moving average for the price development in blue color. The moving average is gives hints about the trend.

Superimposition of OHLC charts is generally not recommended, because the OHLC glyphs would sometimes be overlapping, which would result in unreadable charts. The option of superimposed OHLC charts is therefore not available in the prototype.

The candlestick chart is similar to the OHLC chart. The candlestick glyph uses the colors green and red to display whether the price has increased or decreased.
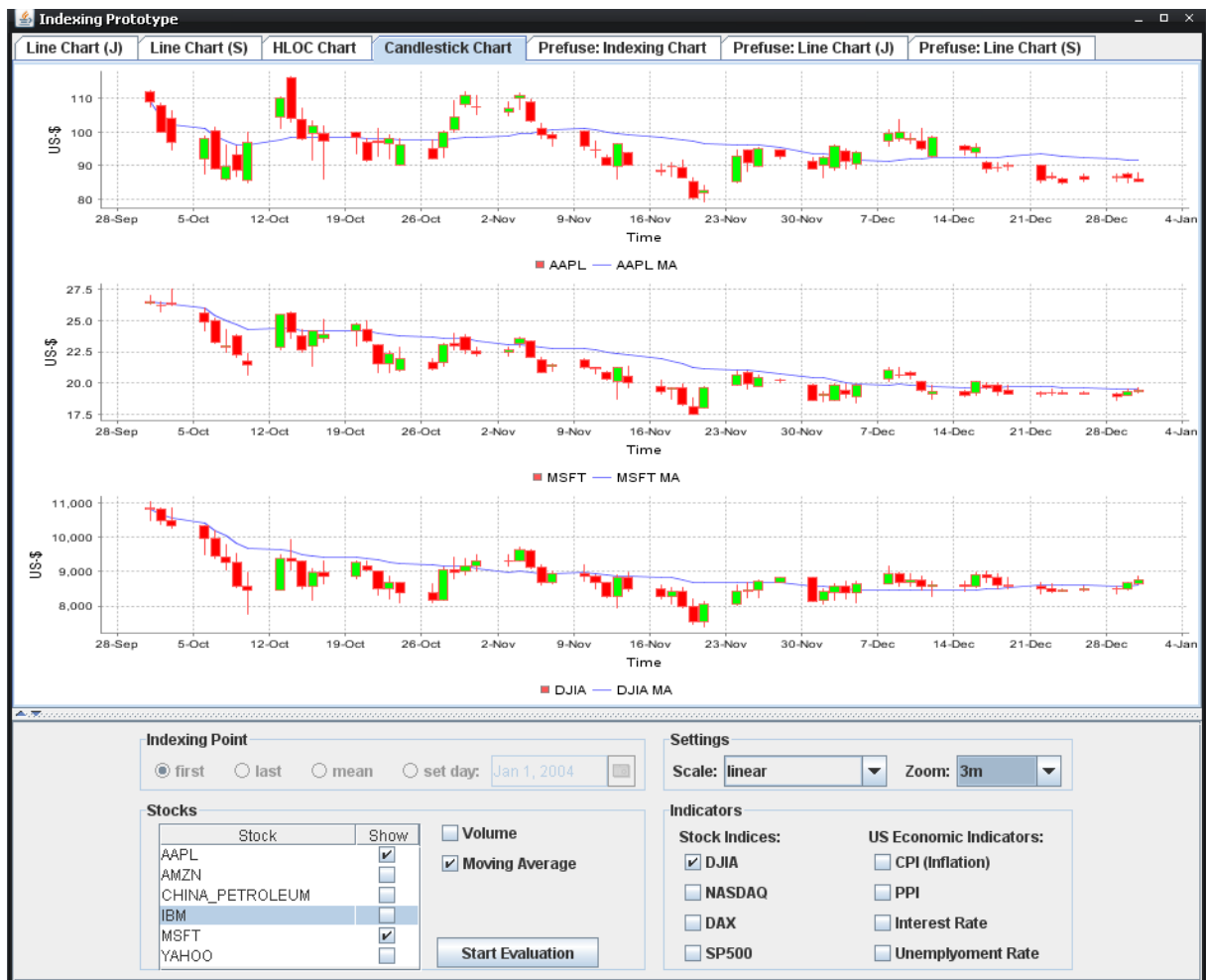

Figure 48: Juxtaposition of three candlestick charts

Figure 48 illustrates three juxtaposed candlestick charts of the same data as in the previous figure of OHLC charts.

Candlestick charts cannot be displayed in superimposition for the same reason as OHLC charts. The candlestick glyphs would be overlapping and thus make the chart unreadable. An option of superimposition of candlestick charts is not available.

Figure 49 shows three stocks and one stock index visualized by a line chart with values according to the indexing method. The indexing point for all stock data is February 1, 2008.
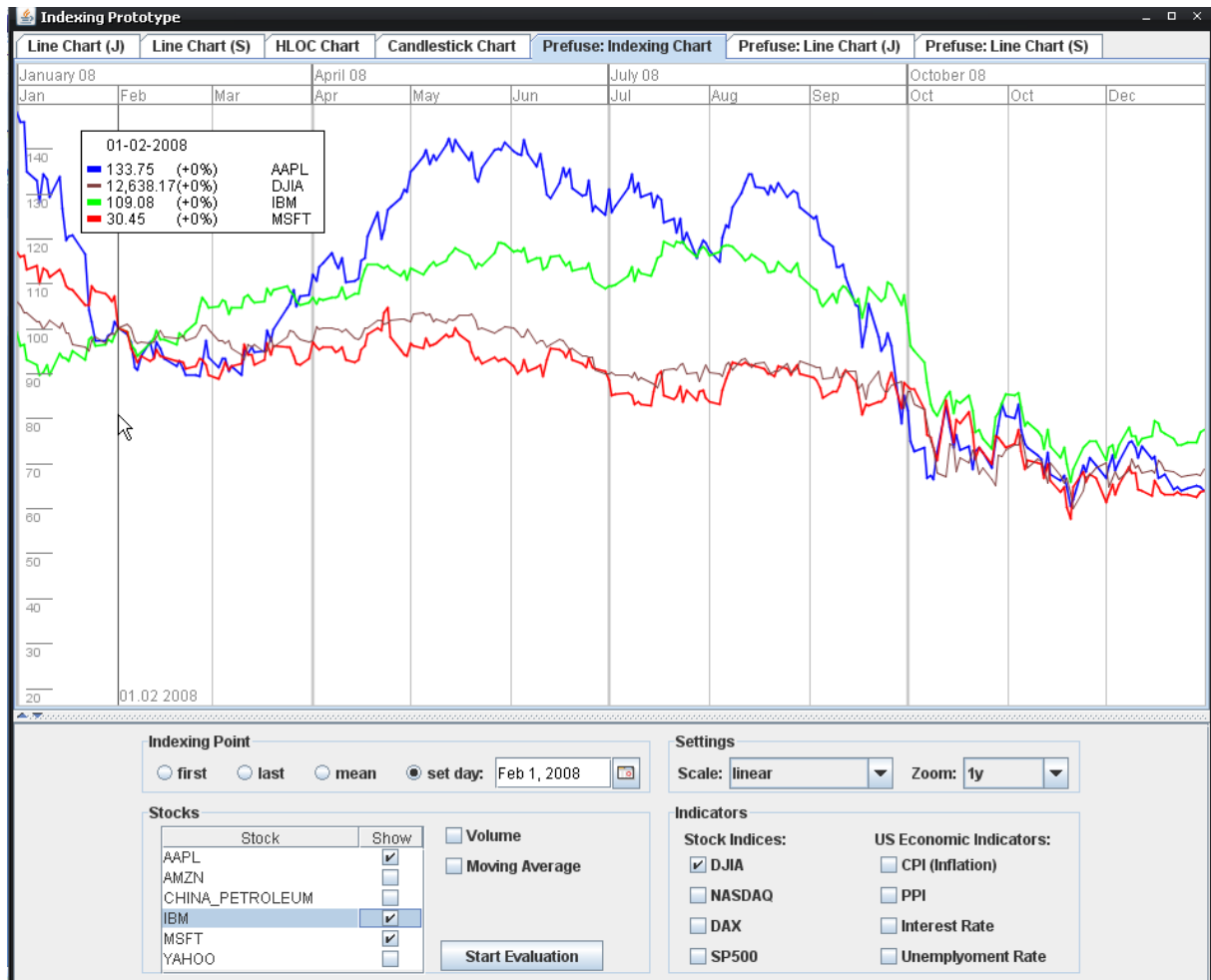

Figure 49: Indexing - Superimposition of four indexed stocks

The user can choose every date as the indexing point as he or she like, then the new charts will be updated based on the indexing point. Each point indicates the rate of growth of a stock based on the indexing points. The date 01.02.2008 was chosen as the indexing point. From the chart visualization, you can notice that from February to June the blue line AAPL has the most percentage increase than other three stocks on the chart. From February to the end of 2008 all stocks' prices declined and IBM has the least percent loss. The indexing chart provides a very easy and intuitive comparison of percent changes of stocks or indices.

The legend is in the upper left corner. It provides details on demand. The legend shows the values which relate to the date which the mouse points to. The date is displayed in the first line of the legend. The following lines relate to the actual prices and the percentage changes of stocks.

5.3 Interactions

This section lists the most important interaction techniques of the prototype.

5.3.1 Zooming and panning

The prototype offers two different zoom functions. One zoom function is executed by mouse selection of an area. While holding the mouse button a rectangle can be drawn on the chart. The size and position of the rectangle represent the zoom boundaries. This function is available for visualizations based on the JFreeChart library such as line charts, OHLC (Opening, Highest, Lowest & Closing prices) charts and candlestick charts. Figure 50 shows the mouse selection zoom. If multiple charts are juxtaposed and the mouse selection zoom is executed, the zoom will be applied to both charts. The charts are linked together which means that they always show the same time range.

The line charts based on Prefuse have a zoom function by mouse wheel instead. By scrolling the wheel up the chart will be zoomed in and by scrolling down the chart will be zoomed out. Also the charts can be moved to the left or to the right by using simple drag and drop actions. This is also called panning.
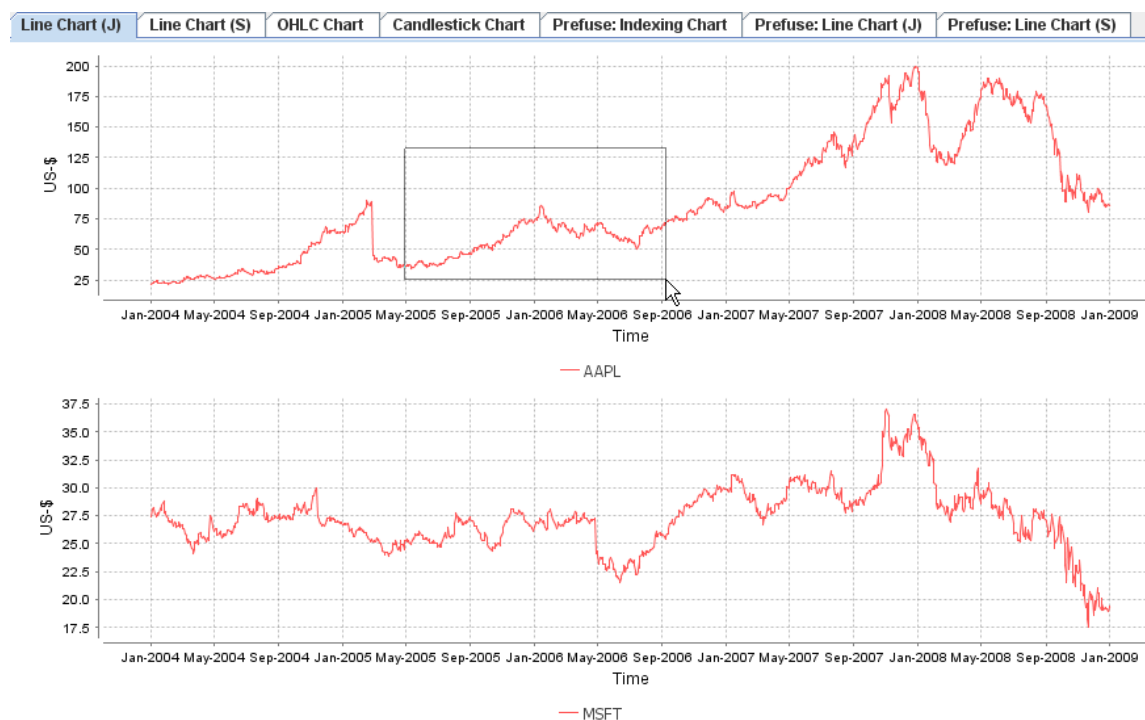

Figure 50: Zoom via mouse selection

There is also a predefined set of standard zoom ranges available in the prototype. The options are 5 days, 2 weeks, 1 month, 3 months, 6 months, 1 year, 2 years and 5 years.

5.3.2 Mousetracker and legend

The Mousetracker is a visual aid for better comparisons and also shows the date at the bottom for the current mouse cursor position. This function is basically a vertical line on all juxtaposed charts which follows the mouse cursor.

The legend is placed in the top left corner. It shows the date according to the mousetracker or respectively according to the mouse cursor position. It also shows name of the visualized data and the value for the current date. When the mouse cursor moves over the legend the background of the legend will become transparent. This can be helpful in situations where the legend is hiding data.
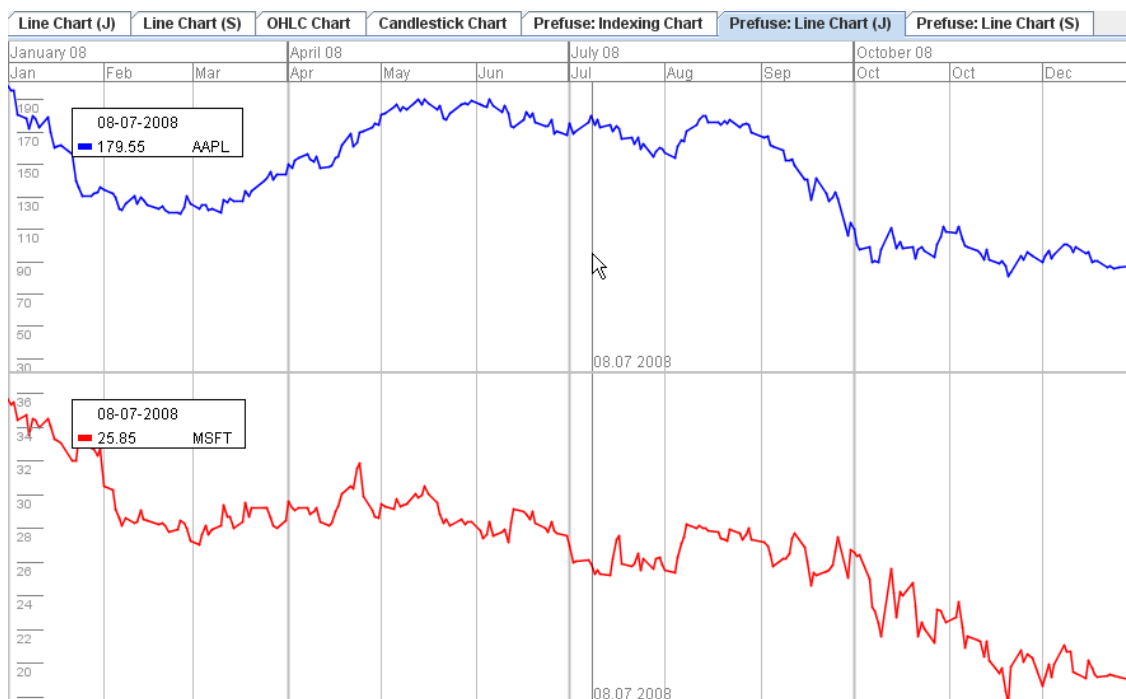

Figure 51: Mousetracker (vertical line) and legend (top left corner)

5.3.3 Setting of indexing point

The indexing point for indexed line charts can be set by the user. Figure 52 is a screenshot of the prototype. The red rectangle marks the area where the indexing point can be set. Available options are first (default), last, mean and a specific day.

The indexing point has a great impact on the visualized data in the chart. A change of the indexing point can make the comparison of the growth rates very easy. The indexed line chart in Figure 52 uses the first day of January 2008 as indexing point.

The blue stock (AAPL) has lost more of its percent value since the first of January than the green (IBM) and the red (MSFT) stocks. This comparison of percent values is
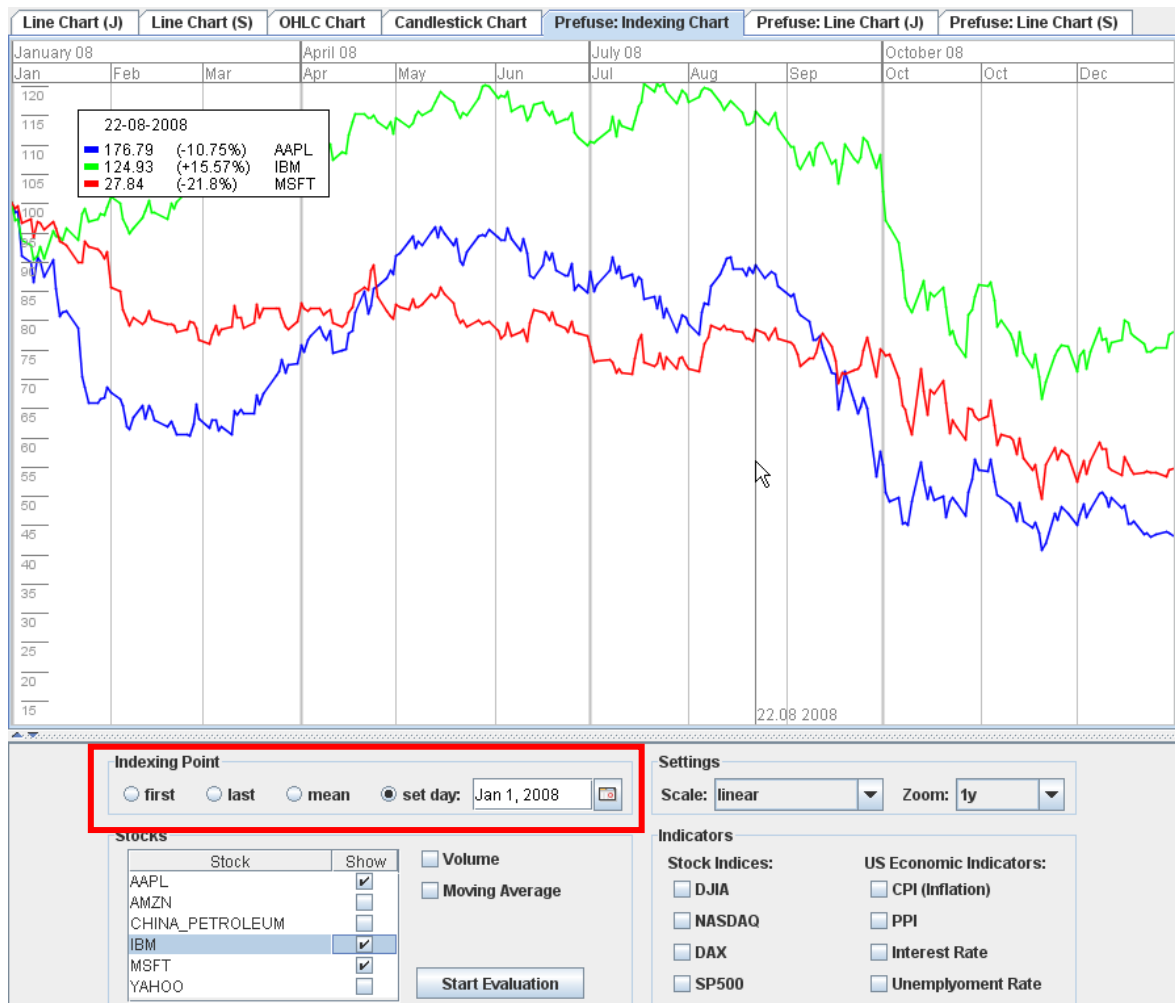
Figure 52: Selection of the indexing point (first, last, mean, specific day)

The indexed chart display percent changes so the displayed time series could also have different units. The indexed line chart can be used to compare the stocks with different currencies or to compare stocks with stock indices or other economic data.

5.4 Architecture

The prototype is written in Java, an object-oriented and widespread programming language. The resulting jar-file contains all code and can be executed on all systems which have a Java Runtime Environment (JRE) installed.

The prototype makes use of some third-party libraries. JFreeChart is a free library to create charts. Another part of the prototype uses the Prefuse Visualization Toolkit. Prefuse is a much more powerful framework for developing visualizations. However there are no charts ready to use out of the box. The application has to define logic, appearance and interactions of the visualization. Fortunately common interactions can be implemented rather quickly by using available classes.

Figure 53 is a package diagram of the prototype application. The main packages are ui, io, util and evaluation. Package ui includes all classes related to the user interface. Obviously this package has the most classes and defines visualizations and their interactions. Package io is responsible for reading of the data files and preparation of the data in java objects for further processing for the visualizations. Package util contains other classes for conversions of data for different visualizations. The package evaluation includes all needed classes for the evaluation mode.
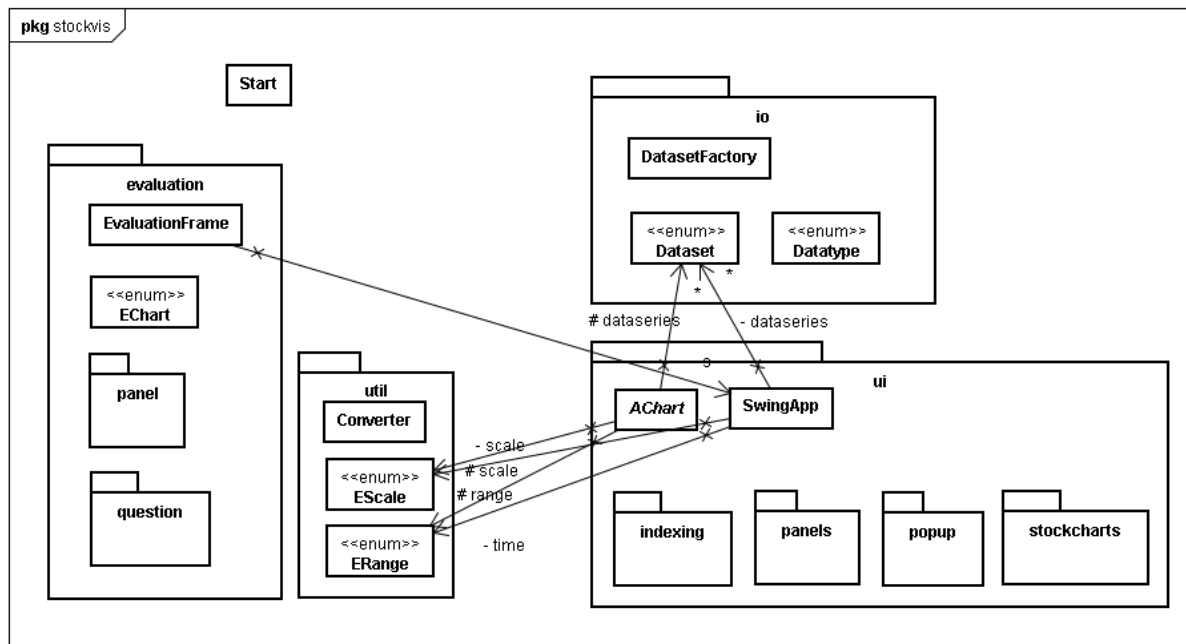

Figure 53: Package diagram [Kainz, 2009]

Figure 54 shows the content of the package indexing within the main package ui. The diagram gives an overview of the complexity for the display of the line chart with the indexing method.

The class IndexingPanel is a façade class for all operations involving the indexed line chart. All changes from outside like the change of the displayed data are communicated with this class only. IndexingPanel includes the class VisuExplorer which is basically handling all visualizations. This class maps the commands from the IndexingPanel class to every line chart. Every line chart is realized by an instance of the VisuExplorer class.

Every VisuExplorer class uses modified versions of JMidgaardViewer and JDataViewer classes. These two classes are based on works of two other projects of the Information Engineering Group. Peter Weishapl developed a prototype which visualizes plans in Java and Prefuse. The homepage of the project is http://ieg.ifs.tuwien.ac.at/projects/timeviewer-timevis/index.html. More information and the prototype itself can be found there. The second project is a prototype of a semantic zoom from Hoffman. The visualization changes dynamically according to the zoom level and is also based on Weishapl's work.

The class DataDisplay is an extension of the class Display. This class uses a lot of other classes which are handling user interactions and also updates the values for the legend. The classes ChangeHandler and PanHandler react when the visualization has been changed. The class ResizeHandler fits the visualization to the available drawing space automatically.

The class MouseTracker paints the mousetracker (vertical line and display of the date) according to the mouse cursor position. When the date of the mousetracker is changed the class DataDisplay is informed and passes the information on to the class Legend.

The class DataVisualization is an extension of the Visualization class and is responsible for the correct display of the visualization. It includes layout classes for switching between linear and logarithmic scales. It also defines how the data is rendered on the screen i.e. it defines how the data is displayed by a line chart.

The class DataPointGraph is an implementation of a data table or a data structure. The Prefuse framework requires that the visualized data is stored in such a graph in order to use it.

Further details about the architecture and implementation are also available in [Kainz, 2009].
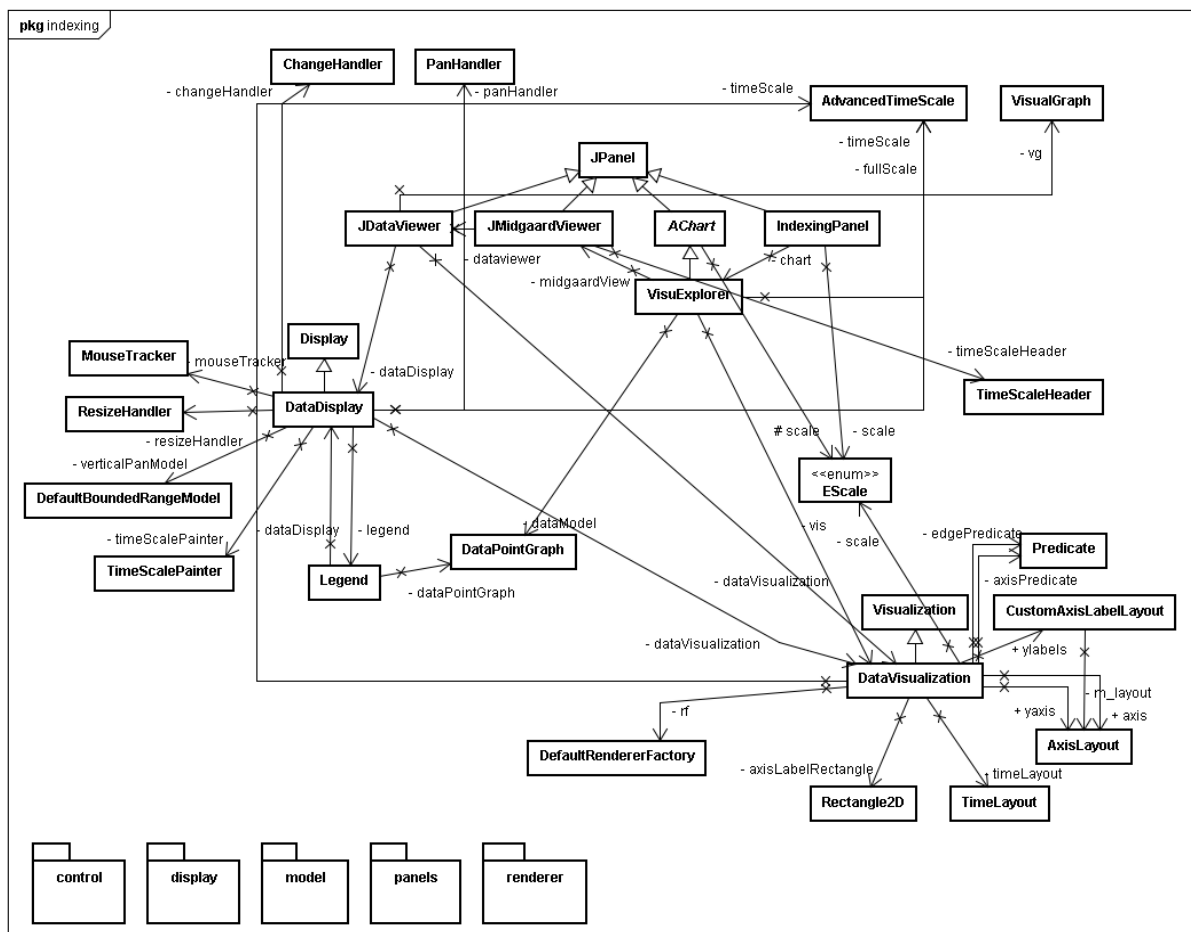

Figure 54: Package Indexing [Kainz, 2009]

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6 User study

The user study is a tool to find out how the different visualization types are suited for visual analysis and comparisons of stock market data.

The focus of the user study is the applicability of interactive visualizations for the stock market area and the general usability of the visualization interactions.

The results of the interviews will help to understand and evaluate the prototype. It is important that the interview partners are domain experts of the stock market field. This increases the value of the statements and may also give new thoughts about the visualizations.

The full questionnaire is available in Appendix B. It contains all central questions for the interviews.

6.1 Interview Goals

The aim of the interview is to gather information about the following key issues.

The first issue is if the domain experts are satisfied with the developed prototype for stock market data. What parts of the prototype should be improved and what parts are good?

How well are the implemented comparison methods for multiple stocks and other stock market data such as stock market indices? Are the basic comparison methods juxtaposition and superimposition useful and what can be improved?

Which of the common stock market charts are best to compare multiple stocks? Available visualizations are line charts, OHLC charts and candlestick charts.

Another key issue is the identification of the main benefits of a linear and a logarithmic scale. Which one of the two scales is preferred by the participants and for what tasks?

The indexing method is an advanced comparison method for multivariate time series. What are the opinions of the domain experts about this method?

Are the users satisfied with the interactive techniques such as panning, zooming and a legend with values depending on the mouse position?

The last goal is to get feedback from the domain experts if economic data is useful for stock price analysis.

6.2 Participants

Five domain experts took part in the user study. All participants work / live in Vienna.

Four of the five interview partners are between 20 and 30 years old. Four are male and all five participants have an academic degree. Two of the five persons have a fulltime job. The other three are studying. Two of the five interview partners have also took part in the requirements interviews. Table 5 shows age, gender, education and job of the participants.

Interview	Age	Gender	Education	Job
A	20 - 30	Male	Bachelor	Student (Business Informatics)
B	20 - 30	Male	Bachelor	Finance Analyst
C	20 - 30	Male	Bachelor	Student (Mechanical Engineering)
D	30 - 40	Male	Master	Accountant
E	20 - 30	Female	Bachelor	Student (Mathematics)

Table 5: User study participants

6.3 Interviews

This section summarizes the main statements and observations for every interview.

The interview length was on average around 40 minutes. In the first 10 minutes of the interview, the interviewer gave a short demonstration of the prototype. This gives the participant an introduction to all available visualizations and interactions.

6.3.1 Interview A

The first domain expert is studying business informatics at the Vienna University of Technology. He is a private stock trader and uses mostly a middle-term strategy (1 to 5 years) for stock investments.

He said that line charts give a quick overview of the development. The closing price movement is an important indicator for him to identify the trend. In order to get more details about the stock he likes to use candlestick charts. This chart provides more information about the volatility of the stock price during the day. He said that it is sometimes important to look at the highest / lowest and opening / closing prices. This is a sign of instability if the values are too far apart from each other. He also thinks that an increased volume is a sign of instability. Opening, highest, lowest, closing prices and volume information are essential to find the right exit point i.e. the right time to sell stocks.

He favors the comparison of multiple stocks by superimposition over juxtaposition. Logarithmic scale is better than linear scale, because it can represent percent changes directly. He argued that the usage of the logarithmic scale has the advantage to display stock prices with great price differences better.

The interview partner likes to use the line chart with the indexing method. According to him, the indexing method can be very useful for comparisons of stocks. Percent changes are directly visible on the chart. The selection of the indexing point is a great function to see the change of the price development from the beginning to the end of a given time period. This makes the comparison of multiple stocks easier. He misses this function in other stock market visualizations.

The interactive functions (zoom via mouse marking or via mouse wheel and panning via drag and drop) are intuitive and easy to use for him. The legend at the top left corner is also a nice feature he said. He likes the automatic scale function of the chart size which adjusts the size of the chart to the available size of the prototype window.

In his opinion no general rules or dependencies between stocks and economic data exist. However he admits that sometimes it is possible to see correlations. For example exchange rates can be important for trading and the oil prices can be influential for transportation companies.

6.3.2 Interview B

The second expert is also studying business informatics at the Vienna University of Technology. He works part time at a hedge funds company. He usually follows a long-term investment strategy (> 5 years). He keeps his stocks usually more than 5 years.

He prefers line charts over OHLC (Opening, Highest, Lowest & Closing prices) charts and candlestick charts. Opening, highest and lowest stock price are not so important to him. He thinks that line charts are better suited to visualize the long time trend.

He criticized the very small horizontal dashes of the OHLC glyph which indicate the opening and closing price. The candlestick chart is better in his opinion, because the red and green colors directly indicate whether the closing price higher or lower than the opening price and the height of the thick part of each candlestick designates the difference between the opening and closing prices very well.

He favors to compare stocks via superimposition, because it is better and easier to compare stock prices than via juxtaposition.

The participant prefers the logarithmic scale over the linear scale. He is interested in the percent changes of the stocks and how much profit can be achieved.

The company where he works has different visualizations for stock market data. It is also possible to use line charts which display values according to an indexing method. The drawback of the software is that the user can not set the indexing point. There are also no interactions like panning and zooming. The legend which shows values depending on the mouse position is a nice feature and makes look up of certain values much easier.

He likes the interactive indexed line chart of the prototype. The interaction and the free selection of the indexing point make it very useful to compare of stocks in his opinion.

Also the interactions zooming (by mouse selection or by mouse wheel) and panning are very useful to him.

The display of economic data is also useful to him. He can analyze whether economic data has influence on stock prices or not.

6.3.3 Interview C

The third interview partner is studying at the Vienna University of Technology. He trades stock since a few years. He usually follows a short term investment strategy (< 1 year).

He thinks that line charts, OHLC charts and candlestick charts are suitable for different purposes. The line chart is accurate when he only wants to know the trend of the stock price over time. He uses the OHLC and candlestick chart when he wants to know more about the details of the stock price development. He prefers OHLC charts and candlestick charts over line charts. Both show opening, highest, lowest and closing prices which are essential to him in order to find price patterns. The patterns can help to determine when he should buy or sell stocks.

He said that the length of days for the moving average should be more customizable. The prototype allows only a 30 days moving average. He suggests including at least 5 days, 10 days and 20 days moving average.

The participant said that comparing stocks by superimposition is more clear and uncomplicated than comparisons by juxtaposition. Problems occur when the stocks have different currencies (e.g. dollar, euro, pound, etc.) or the stock prices are too far apart. In this case he prefers to compare stocks by juxtaposition. If he wants to compare stocks with OHLC charts or candlestick charts, he also uses comparisons by juxtaposition. His trading program does not allow stock comparisons by juxtaposition. He has to use a graphics editing program like Adobe Photoshop to place the charts next to each other. Then he is able to compare the stocks at the same time through juxtaposition.

The interview partner said that a logarithmic scale is useful when the price ranges are too far apart. A logarithmic scale reduces the visual difference, which is better suited to visually analyze the development of the data. When the difference between the price ranges is small enough, the test person prefers to use a linear scale.

The indexed line chart is better in his opinion than the traditional line chart, because it does not compare the absolute stock prices, but rather the percent changes of the stock prices. The free selection of the indexing point is helpful.

The zoom function is very useful for the stock analysis for a certain time range he said. He added that it is important that zoom in and out is available. The legend which shows values depending on mouse position is very interactive and useful to him. It allows to lookup values for an important date in a simple way.

He thinks that economic data can influence stock prices. He compares economic data and stocks to find relations between economic and finance data. Besides CPI, PPI, interest rate and unemployment rate, the oil prices and international futures contracts may also be of importance, but this is different for each stock.

6.3.4   Interview D

The fourth participant is an accountant. He prefers a long term investment strategy (> 5 years), because he thinks that the long term price development represents the company's position better than the short term price development. He usually analyzes stocks at a long time range. The long term price changes are generally more stable than short term price movements. There are many factors that can influence the stock price he said.

He prefers to use OHLC charts and candlestick charts, because they show opening prices, highest prices, lowest prices and closing prices. Both charts indicate whether the price increases or decreases for each time period. For long term analyses of the stock price he uses line charts to determine a general trend. OHLC charts and candlestick charts are more suited for a short term analysis according to him.

The interview partner likes to compare stocks in one diagram, because this allows comparing the values directly. He said that comparisons by juxtaposition require more attention to read the prices according to the y axis. The values have to be looked up, remembered and mentally compared. This is much harder than to visually compare them he said.

In his opinion the usage of a logarithmic scale can help to compare the growth rate and the volatility of stocks.

He believes that every chart has its own advantages and disadvantages. While the indexing method is suitable for comparisons of growth rates of the stock price, it is not good for comparisons of the absolute prices for a certain day. He also thinks that it is also not so good for comparisons of the volatility of stocks. He criticized that the indexed line chart cannot show the opening prices, highest prices and lowest prices like the OHLC chart and the candlestick chart.

The participant said that the manual setting of the indexing point is very useful and important for him. The user can compare the percentage changes of stocks based on different starting points in time.

He is satisfied with the legend which shows values according to the mouse cursor position. However he would like to change the position of the legend on the chart with a drag and drop action, because the legend is sometimes covering parts of the stock price on the charts.

He considers the zoom function in line, OHLC and candlestick charts (i.e. charts based on JFreeChart) very useful and easy to use. He suggests that during the zoom process the boundary dates at the left and right border should be displayed. This way the user knows exactly the time range of the zoom.

He said that the zoom function of the indexed line chart (i.e. chart based on Prefuse) should provide a zoom function by mouse selection. The dates for the left and the right boundaries should be displayed. He likes to use a time slider zoom function (similar to Google Finance). The time slider shows an overview of the whole data at the bottom of the main

chart. The user can select a certain time period of the data via the slider. The data of the selected time period is than shown on the main chart.

In his opinion some economic data like interest rate can have a influence on stocks, because many people will alter their investment decisions if the interest rate changes. He thinks that if the interest rate is increasing, than a lot of people will put their money in a savings account instead of stocks. Savings are in most circumstances less risky and the interest rate is fixed or at least the value is known. He often noticed that if the interest rate is decreasing, more people will invest in stocks because they want to get more profit by investing in stocks.

He said that it doesn't make any sense to compare economic data with individual stocks. Some stocks are too volatile so it is best to compare economic data with stock indices or a group of stocks which belong to the same industry. The user gains more information and correlations are more effective than by comparing economic data against individual stocks.

There is other important economic data besides the ones used in the prototype application he said. Two major economic indicators are GDP (gross domestic product) and exchange rates. The interest rate and the exchange rates can have influences on each other.

6.3.5 Interview E

The fifth participant is studying mathematics at the Vienna University of Technology and favors a short term investment strategy (< 1 year).

She favors candlestick charts over line charts or OHLC charts. Because candlestick charts provide additional information about opening price, highest price, and lowest price compared to a simple line chart. Therefore candlestick charts are more suited to analyze short term stock price development in her opinion. Candlestick glyphs make use of red and green colors for a better visual distinction between increases and decreases of the price. OHLC glyphs use horizontal dashes to represent the opening and closing prices. However it is not as visually effective as candlestick glyphs. She said that it takes more time and effort to analyze the stocks by using OHLC charts than by using candlestick charts.

The interview partner prefers to perform comparisons with superimposed line charts. However if the difference between the prices ranges of the displayed stocks is too large, the lines become distorted or flattened. In such cases she compares the data by juxtaposition. She also said that OHLC charts and candlestick charts can only be compared by juxtaposition. She suggests making the arrangement of juxtaposed charts customizable. This can be executed with a simple drag and drop action. This interaction would let the user decide which data is placed next to each other.

She prefers to use a logarithmic scale instead of a linear scale. A logarithmic scale stores information about the percent change between two points into the slope of the connected line. The slope can be used to determine and distinguish between growth rates of various lines within one stock and also among multiple stocks.

In her opinion the indexing method looks promising for comparison tasks about growth rates for stock prices. The indexing method can show the user immediately which stock has a greater percent increase and which one has most percent lost. The percent values are easy to identify from the chart. It should also be well suited for comparisons of stocks with difference currencies or comparisons of stocks against other data such as stock indexes and economic data.

However the problem of the indexing method is the lack of absolute values. She thinks that if someone wants to compare absolute values of the stock price, the method can lead to false conclusions about the data.

The participant believes that the free selection of the indexing point is a vital part for effective comparisons. She said that the indexing date is quite important for comparisons of the development of multiple time series. For example, when someone buys stocks at a certain date, it would be great to compare the particular stock against alternative stock choices. Through the comparison, the user is able to see the performance of the stock and the alternative stocks and can determine if the decision to buy was right.

The interview partner is extremely satisfied with the dynamic legend that displays values according to the mouse cursor position. She said that this is very interactive and allows quick lookup of values.

The MouseTracker, a vertical line representing the current horizontal mouse position, displays the date for the current position. She suggests that the value for the according date should be additionally highlighted through a bigger point. This would be a good visual aid to find the value for the current date. It would also help to determine its relation (e.g. higher or lower) to the other values.

The zoom function of the line chart, OHLC chart and candlestick chart is interactive and very useful for her. The mouse wheel zoom function is ok, but a zoom by mouse selection would be faster and more precise she said. The panning function and the automatic resize of the charts depending on the application window size are excellent.

It is often important for her to compare stocks against stock market indices to determine how well other stocks are performing. A more general trend about the involved stocks can be analyzed and may give information about the current trend of similar stocks.

She thinks that economic data sometimes has influence on stocks. But it is difficult to define the influence of economic data such as on stock market data and vice versa. The effects between them are not instantly visible she said. There may be weeks between the source event such as a stock market crisis and the consequences on the real economy. This makes a simple observation impossible. However some economic models might help in such situations.

For example stock prices can affect economic data like unemployment rate and GDP in rare situations. A decline of stock market indices does sometimes lead to higher unemployment rates, which has itself a negative effect on parts of the economy.

6.3.6 Summary

Line charts are often used for gathering trends of the time series. They are better for middle term and long term analysis. Other stock visualizations such as OHLC charts and candlestick charts are better for short term analysis. The focus is put on characteristics of the daily stock prices. The additional price information is useful for quick responses to the stock market behavior.

Most interview partners (A, B, C and E) prefer candlestick charts over OHLC charts, because colors are easier to recognize than horizontal dashes. The colors can show the differences between the closing and the opening prices more efficient.

All interview partners thought that, superimposition is better than juxtaposition, because all stocks can be displayed in one chart. Comparisons by juxtaposition require more attention to read the prices according to the y axis. The values have to be looked up and be compared. The interview partner C and E have mentioned that, the comparison by juxtaposition has its advantage when the stocks have different units. For example, the stocks have different currencies. Juxtaposition is also useful when the price ranges are very large. Superimposition would flatten the lines and remove any possibility to detect changes. Complex glyphs like the OHLC and candlestick glyphs are not suited for comparison by superimposition. Therefore only juxtaposition is used for comparing these charts. Interview partner E suggested that a drag and drop would be useful to compare them by juxtaposition because the charts can be placed next to each other when needed.

Most interview partners prefer a logarithmic scale over a linear scale, because it is easier to compare the percent changes of stocks. A linear scale is useful to compare the absolute values or absolute changes, but cannot be used for comparing percent changes. A logarithmic scale is also useful when the prices ranges are too far apart. Because the visual difference between the values is decreasing exponentially (Interview A and C).

The participants did have no troubles understanding the indexing method. The method is satisfied by all interview partners. It is better than other comparison methods for comparing the growth rates. This is important for analysis of stock prices, because the growth rate relates to the profit from the investment of the stocks. The indexing method can also be used for comparing the stocks with different currencies, comparing stocks with stock indices or comparing stocks with other economic time series.

The free selection of the indexing point is thought by all interview partners as an important and useful function, because the user can compare the percent changes of stocks based on the values of different dates. This feature is missing in most other stock market visualization applications (Interview A).

The interactive functions are positively received by all interview partners. The zoom function is intuitive and useful to all. Interview partners D and E think that an optionally rectangular selection would be a good alternative zoom function. The user can specify the desired zoom area more precisely through the selection. The zoom function by rectangular

selection could display the dates for the left and the right boundary (Interview D). This would further increase the precision for zooming operations.

A small overview chart at the bottom of the visualization would give an outline of the whole data. The user could specify the zoom range via a range slider on the overview chart (Interview D).

All five participants think that the dynamic legend which shows values depending on the mouse position is a success. Interview partner D suggests that the legend box should be movable, because it hides sometimes underlying data. Interview partner E suggests highlighting the values for the current mouse position by bigger points. This would increase the ability of visual identification of the current values.

The technical indicator moving average should have more available options to select common length such as 5 days, 10 days, 20 days and 30 days. It would also be good to set the amount of days as parameter (Interview C).

It is useful to compare economic data against stock indices or certain group of stocks (Interview D). Individual stocks are often too volatile to follow the overall trend. According to interview C, each stock is responding differently to economic events and developments.

The influence of economic data on stocks is hard to define. Many factors may affect the stock price. It is not feasible to derive rules about the economy and its influence on stock markets and vice versa (Interview A and E).

6.4 Related Comparison Study

The prototype application was created in combination with a second master thesis. The subject of the other thesis is a comparative study between the three following comparison methods:

- Juxtaposed line charts with linear scale

- Superimposed line charts with logarithmic scale

- Line chart with indexing method

24 participants took part in the comparative study. The focus of the study is to measure task completion times and task correctness rates for comparison tasks for each of the three visualization types mentioned above.

The comparative study uses the task taxonomy and results of the user task analysis which are described in the previous chapter. Further details are available in [Kainz, 2009].

The first point of the main findings of the comparative study is that the usage of logarithmic scales leads to significantly faster task completion times, which has no impact on the task correctness rate, compared to linear scales in percent estimation tasks.

The second point states that indexing method shows significantly higher task correctness rates for percent estimation tasks, trend comparison tasks and for all 14 user tasks com-

pared to the two other tested visualizations types. The task completion times do not show any significantly differences.

The third point is that the majority of the 24 test users favor the indexing method to compare multiple stock market data when they were asked to choose one visualization type after the test.

7 Conclusion & Future Work

Visualizations of stock market data can help people to understand the data and the trend much easier than numerical values. Many investors like to compare stocks and stock market indices with line charts. Other stock market visualizations like OHLC (Opening, Highest, Lowest & Closing prices) charts and candlestick charts can show additional price information like opening, highest and lowest prices. But they are not very well suited for comparisons, because the data has to be compared by juxtaposition only.

The user & task analysis provided feedback for the development and for the evaluation of the stock market visualization prototype. Line charts are better for identifying the general trend of the data, which is important for long term investments. OHLC and candlestick charts give more information about the price fluctuation and thus are superior for short term investments.

All participants of the user study think that superimposition is a better comparison method than juxtaposition. However superimposition is difficult when multiple units are involved.

The majority of the participants prefer to use a logarithmic scale for comparisons of stock market data. It is better at showing percent changes and it is also useful for data which price ranges are greatly different.

The five domain experts agreed that the indexed line charts are better for comparing percent changes of stocks. The indexing method allows displaying all kinds of stock market data by superimposition in only one chart. All indexed data share the same dimension of percent changes based on the value of the indexing point, which allows direct comparisons of percent changes. This makes comparisons much more effective. The ability to freely define the indexing point is an important and useful function for all participants.

Comparisons of stock market data with economic data are often not very purposeful. It is better to compare a group of stocks or a stock market index with economic data like GDP or interest rates. The stock market and economic data correlates better when individual effects of single stocks are removed.

Future Work

Several participants suggested improving the zoom interaction via mouse selection. The zoom function should show the first date and the last date of the selected area during the action, so that the user exactly knows the time range of the zoom. This would make zooms more precise.

Another way to enhance the zoom function is to include a special component such as the time slider. This component is located at the bottom of the chart and enables the user to zoom in or out by using two arrows.

The order of juxtaposed charts should be rearrangeable. For example this can be realized by using a drag and drop action. This way the user can place the stocks next to each ac-

cording to the current needs. This should improve comparisons by juxtaposition with more than two charts.

The effects of the indexing point for comparisons can be tested in more detail. It would be interesting to determine the differences between various indexing points i.e. first, last, mean, highest, lowest or another special day influence the display and subsequently the effectiveness and efficiency of multivariate comparisons.

But also the selection of the indexing point can be further investigated. A more dynamic setting based on the current mouse cursor position, similarly to the mousetracker, can be tested. The user would not need to set the indexing point manually any more.

Another method would be to use a marker on the chart, which can be moved by a drag and drop action. The position of the marker is defining the indexing point. This would certainly add a greater interaction and would probably speed up the comparison tasks.

Also the indexing method should be tested for its applicability in other application areas, where comparisons of multivariate data is also useful. Further areas can include health, climate and government data.

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Appendix A: User & Task Analysis

Because the material was prepared in German, this section is written in German.

A1 Interview Guideline

Fragen über Tasks:

1. Wie vergleichen Sie zwei oder mehrere Aktienkurse grafisch miteinander?

2. Gibt es Probleme bei dem Vergleichen? Wenn ja, welche?

Fragen über Visualisierung:

3. Welche Art von Diagrammen verwenden Sie? (e.g. Line charts, Bar charts, Candlesticks)

4. Über welchen Zeitraum werden die Kurse üblicherweise beobachtet?

5. Wie nützlich sind diese Diagramme für Sie?

Fragen über interaktive Visualisierung:

6. Verwenden Sie interaktive Visualisierungstechniken, z.B. Zoomen, Filtern, Anzeige von Kurswerten anhängig von der Mauszeigerposition? (zum Beispiel http://www.google.com/finance)

7. Sind sie mit den interaktiven Möglichkeiten zufrieden?

Fragen über Daten:

8. Welche Daten werden in den Diagrammen angezeigt bzw. welche Daten sind wichtig?

9. Gibt es Aktienkursen, die sich gegenseitig beeinflussen?

10. Welche anderen Daten könnten Ihrer Meinung nach mit Aktienkursen korrelieren?

11. Sollte man diese Daten aus Frage 10 als punktuelle Ereignisse (z.B.: Veränderung um 10 %) oder als Kurve über die ganze Zeit darstellen?

A2 Interviews

A2.1 Interview A

1. Welche Tasks werden benötigt um zwei oder mehrere Aktienkurse grafisch miteinander zu vergleichen?

IP 1: Zuerst werden die Daten in einer internen Datenbank gespeichert. Die Daten werden über spezielle Feeds in Echtzeit übertragen.

Es gibt ein eigenes, entwickeltes Tool zur grafischen Darstellung der Daten. Das Programm zeigt die eingestellten Kurse in prozentuellen Werten an. Dies dient zum schnellen und groben erkennen der Verläufe. Danach werden die Daten in eine Excel-Datei exportiert. Die Daten werden in einem bestimmten Format abgespeichert, damit andere Programme und Excel-Makros diese neuen Dateien auswerten können. Hauptsächlich werden die Kurse numerisch analysiert.

2. Gibt es Probleme bei dem Vergleichen? Wenn ja, welche?

IP 1: Es wird nur augenscheinlich grafisch überprüft, ob es große Ausreißer gibt. Die eigentliche Analyse ist numerisch durch VBA-Makros.

3. Welche Daten werden in den Diagrammen gezeigt?

IP 1: Die Diagramme zeigen die prozentuellen Veränderungen der Hedgefonds an.

4. Gibt es Aktienkursen, die sich gegenseitig beeinflussen?

IP 1: Grundsätzlich sind Abhängigkeiten sehr komplex und nur begrenzt gültig.

5. Welche anderen Daten könnten Ihrer Meinung nach mit Aktienkursen korrelieren?

IP 1: Wechselkurse haben einen Einfluss auf Import / Export. Steigt der Wechselkurs werden die exportierten Waren teurer und somit wird weniger gekauft. Dies kann Folgen auf den Umsatz des Unternehmens haben.
Gold / Silber wird gerne in Krisenzeiten gekauft, da Edelmetalle relativ stabile Preise haben. Ein Anstieg des Gold bzw. Silberpreises könnte also bei einer schwachen Wirtschaft auftreten.
Die Festlegung des Leitzinses ist ein Regulierungsmittel der Nationalbanken um mehr Geld in Umlauf zu bringen. Durch „billigere" Kredite (niedrige Zinsen) wird im Allgemeinen mehr investiert. Erstens sind Aktien als Alternative zu Sparbüchern ertragreicher und zweitens gibt es mehr Kapital im Umlauf das investiert werden kann.

6. Wie könnte man sie darstellen?

IP 1: Als Liniendiagramme um die Unterschiede besser zu erkennen zu können.

7. Welche Art von Diagrammen verwenden Sie? (e.g. Line charts, Bar charts, Candlesticks)

IP 1: Liniendiagramme zur schnellen und groben Vergleich von selektierten Hedgefonds. Für Kunden werden Liniendiagramme und Balkendiagramme erstellt.

8. Über welchen Zeitraum werden die Kurse üblicherweise beobachtet?

IP 1: Abhängig von dem Alter des Kurses, jedoch min. 1 Jahr beim schnellen vergleich und 1 Jahr für den Kunden im Jahresbericht.

9. Woher bekommen Sie die Diagramme?

IP 1: Die Diagramme werden von einer eigenen Applikation generiert.

10. Wie nützlich sind diese Diagramme für Sie?

IP 1: Sie liefern einen schnellen Überblick. Für echte Entscheidungen werden numerische Analysen durchgeführt.

11. Wie oft verwenden sie diese Diagramme?

IP 1: Die Diagramme werden zu ca. 10 % verwendet. 45 % numerische Analysen und 45 % aus persönlichen Gesprächen mit den Verantwortlichen der gehaltenen Hedge Fonds.

12. Verwenden Sie interaktive Visualisierungstechniken, z.B. Zooming, Filtern, Genaue Anzeige der Werte anhängig von Mauszeigeposition (Details on Demand), Historie, Wertebereich einschränken?

IP 1: Nein wir verwenden keine interaktiven Visualisierungen. Allerdings sind manche Eigenschaften sehr hilfreich. Zooming, Anzeige der Werte für Mausposition sind sicher gut geeignet. Auch die Möglichkeit der Treemap- Darstellung von Aktien ist sehr interessant und zeigt sehr gut die Charakteristiken (Veränderung des Preises durch Farbe, Trading Volumen durch Größe, Zugehörigkeit zu einem Sektor durch hierarchische Positionierung, Korrelationen in den täglichen Veränderungen durch gleiche Farbe) der Aktienkurse.

A2.2 Interview B

1. Wie vergleichen Sie zwei oder mehrere Aktienkurse grafisch miteinander?

IP 2: Mit der Software WISO Börse 9.0.

2. Gibt es Probleme mit dem grafischen Vergleichen? Wenn ja, welche?

IP 2: Ja, wenn die Charts linear dargestellt werden statt exponentiell.

3. Welche Art von Diagrammen verwenden Sie? (z.B.: Liniendiagramme, Balkendiagramme, Candlestick)

IP 2: Beim Betrachten von nur einem einzigen Chart → Candlesticks
Beim Vergleichen mehrerer Charts → Liniendiagramme, aufgrund der Übersichtlichkeit

4. Über welchen Zeitraum beobachten Sie üblicherweise die Kurse?

IP 2: Sowohl langfristig (> 10 Jahre) als auch kurzfristig (wenige Stunden), je nachdem, welche Anlagestrategie ich mit dem Investment verfolge.

5. Wie nützlich finden Sie diese Diagramme?

IP 2: Sehr nützlich

6. Verwenden Sie interaktive Visualisierungstechniken, z.B. Zoomen, Filtern, Anzeige von Kurswerten anhängig von der Mauszeigerposition? (zum Beispiel http://www.google.com/finance)

IP 2: Ja, alle, solange die Übersicht dabei nicht verloren geht.

7. Sind sie mit den interaktiven Möglichkeiten zufrieden?

IP 2: Jain, die Zoommöglichkeiten sollten verbessert werden. Generell müsste alles intuitiver gestaltet werden. Und kostenlose Realtime-kurse sollten verfügbar sein!

8. Welche Daten werden in den Diagrammen angezeigt bzw. welche Daten sind wichtig?

IP 2: Eröffnungs-, Höchst-, Tiefst- und Schlusskurse. Dann natürlich der Zeitraum und eine harmonische Farbgestaltung des Charts.

9. Gibt es Aktienkurse, die sich gegenseitig beeinflussen?

IP 2:--

10. Welche anderen (volkswirtschaftlichen) Daten könnten Ihrer Meinung nach mit Aktienkursen korrelieren?

IP 2:--

11. Sollte man diese Daten aus Frage 10 als punktuelle Ereignisse (z.B.: Veränderung um 10%) oder als Kurve über die ganze Zeit darstellen?

IP 2:--

A2.3 Interview C

1. Wie vergleichen Sie zwei oder mehrere Aktienkurse grafisch miteinander?

IP 3: Auf onvista, falls möglich.

2. Gibt es Probleme mit dem grafischen Vergleichen? Wenn ja, welche?

IP 3: Zu kurze Zeiträume; Nicht immer alle Daten verfügbar; unübersichtlich.

3. Welche Art von Diagrammen verwenden Sie? (z.B.: Liniendiagramme, Balkendiagramme, Candlestick)

IP 3: Linie und Candlestick Diagramme.

4. Über welchen Zeitraum beobachten Sie üblicherweise die Kurse?

IP 3: 5-10 Jahre.

5. Wie nützlich finden Sie diese Diagramme?

IP 3: Bedingt nützlich.

6. Verwenden Sie interaktive Visualisierungstechniken, z.B. Zoomen, Filtern, Anzeige von Kurswerten anhängig von der Mauszeigerposition? (zum Beispiel http://www.google.com/finance)

IP 3: Nein, noch nicht.

7. Sind sie mit den interaktiven Möglichkeiten zufrieden?

IP 3: Könnte noch weiter ausgebaut werden.

8. Welche Daten werden in den Diagrammen angezeigt bzw. welche Daten sind wichtig?

IP 3: Relative und absolute Werte über möglichst lange Zeiträume.

9. Gibt es Aktienkurse, die sich gegenseitig beeinflussen?

IP 3: Alle Kurse beeinflussen sich irgendwo gegenseitig.

10. Welche anderen (volkswirtschaftlichen) Daten könnten Ihrer Meinung nach mit Aktienkursen korrelieren?

IP 3: Die Korrelationen ändern sich ja ständig → keine feste Aussage möglich.

11. Sollte man diese Daten aus Frage 10 als punktuelle Ereignisse (z.B.: Veränderung um 10%) oder als Kurve über die ganze Zeit darstellen?

IP 3: Beides.

A2.4 Interview D

1. Wie vergleichen Sie zwei oder mehrere Aktienkurse grafisch miteinander?

IP 4: Gehe auf Fondsweb, bzw. Cominvest und Cortal Consrors.

2. Gibt es Probleme mit dem grafischen Vergleichen? Wenn ja, welche?

IP 4: Die Vergleiche bei Fondsweb sahen früher besser aus und waren Informativer, heute ist die Seite zu bunt und unübersichtlich.

3. Welche Art von Diagrammen verwenden Sie? (z.B.: Liniendiagramme, Balkendiagramme, Candlestick)

IP 4: Verschiedene, Linien, Kuchendiagramme meist.

4. Über welchen Zeitraum beobachten Sie üblicherweise die Kurse?

IP 4: Lang, mittel und Kursfristig in verschiedenen Tabellen.

5. Wie nützlich finden Sie diese Diagramme?

IP 4: Die sagen nur über die Vergangenheit aus, es gibt aber durchaus Möglichkeiten von technischen Linien die aussagen über den Trend liefern können.

6. Verwenden Sie interaktive Visualisierungstechniken, z.B. Zoomen, Filtern, Anzeige von Kurswerten anhängig von der Mauszeigerposition? (zum Beispiel http://www.google.com/finance)

IP 4: Google eher selten, nur wenn auf meinen Seiten nichts über eine Neue Aktie oder Firma zu finden ist.

7. Sind sie mit den interaktiven Möglichkeiten zufrieden?

IP 4: Nicht immer, aber immer öfter.

8. Welche Daten werden in den Diagrammen angezeigt bzw. welche Daten sind wichtig?

IP 4: Kurse, Kursgewinnverhältnis, Markowitz Matrix.

9. Gibt es Aktienkurse, die sich gegenseitig beeinflussen?

IP 4: Ja die gibt es, alles schaut meist auf den DOW, der ist der Leithammel, das ist aber auch nur die grobe Richtung, sonst wenn Aktien fallen steigen Anleihen, und in diesen Zeiten steigen eher Konsum und Gebrauchsgüter und bestimmte Rohstoffarten und andersrum fallen diese dann auch wieder, wenn die Börsen wieder steigen. Leitzinsen und Diskontsätze spielen auch eine große Rolle.

10. Welche anderen (volkswirtschaftlichen) Daten könnten Ihrer Meinung nach mit Aktienkursen korrelieren?

IP 4: Wenn eine Volkswirtschaft ein höheres BIP hat als andere, Großveranstalltungen bei denen die ganze Welt zuschaut z.B. Olympiade oder Fußball WM & EM.

11. Sollte man diese Daten aus Frage 10 als punktuelle Ereignisse (z.B.: Veränderung um 10%) oder als Kurve über die ganze Zeit darstellen?

IP 4: Kann man evtl. extra machen, sollte man mit einem Haken auswählen können.

A2.5 Interview E

1. Wie vergleichen Sie zwei oder mehrere Aktienkurse grafisch miteinander?

IP 5: Ich verwende Line Charts um die Preise von Aktien innerhalb eines Tages zu vergleichen.
Ich verwende Candlestick Charts, um die Preise von Aktien in einem Zeitraum von z.B. einer Woche, zwei Wochen, ein Monat oder drei Monate zu vergleichen.

2. Gibt es Probleme mit dem grafischen Vergleichen? Wenn ja, welche?

IP 5: Ja, wenn zwei Stocks einen ähnlichen Verlauf haben, dann reicht die technische Analyse nicht aus. Ich vergleiche dann folgende Daten:

1. Zuerst werden die Aktiensektoren, zu den die Aktien gehören, verglichen. Wenn ein Aktiensektor nicht gut ist, dann werde ich die dazugehörigen Aktien nicht berücksichtigen.
2. Vergleich von Firmen-Informationen, z.B. Firmenprofit, Firmenumsatz, Kurs-Gewinn-Verhältnis (KGV), , Gewinn je Aktie, Dividende, usw.
3. Für kurzfristige Vergleiche, berücksichtige ich noch „Inflows" und „Outflows". (http://en.wikipedia.org/wiki/Stock_and_flow).

Da mein Programm nicht die Aktien mittels Candlestick Darstellung vergleichen kann, muss ich selbst einen Screenshot für jede Aktie machen und mit Hilfe von Photoshop die Aktien untereinander legen. Dann kann ich die Aktien besser vergleichen.

3. Welche Art von Diagrammen verwenden Sie? (z.B.: Liniendiagramme, Balkendiagramme, Candlestick)

IP 5: Line charts für Tagesverlauf von Aktienwerte.
Candlestick für Verlauf von Aktienwerte.
Balkendiagramme für Volumen.

4. Über welchen Zeitraum beobachten Sie üblicherweise die Kurse?

IP 5: Ich beobachte die Aktienkursen von 1 Tag, 5 Tage, 10 Tage, 1 Monat oder 1 Jahr.

5. Wie nützlich finden Sie diese Diagramme?

IP 5: Sehr nützlich.

6. Verwenden Sie interaktive Visualisierungstechniken, z.B. Zoomen, Filtern, Anzeige von Kurswerten anhängig von der Mauszeigerposition? (zum Beispiel http://www.google.com/finance)

IP 5: Zooming:
- Einfach Diagramm vergrößern
- Zeitraum vergrößern

Anzeige von Kurswerten und auch Datum anhängig von der Mauszeigerposition

7. Sind sie mit den interaktiven Möglichkeiten zufrieden?

IP 5: Ja.

8. Welche Daten werden in den Diagrammen angezeigt bzw. welche Daten sind wichtig?

IP 5: Die Preise von den Aktien (open, high, low und close), das Volumen und der Moving Average.

Die Beziehung zwischen Preis und Volumen ist wichtig für mich. Die Preisänderung muss mit der Änderung des Volumens übereinstimmen. Wenn das Volumen steigt, ist die Nachfrage höher als das Angebot. Das führt dazu, dass die Aktienpreise steigen werden. Umge-

kehrt gilt, wenn das Volumen sinkt, dann ist das Angebot höher als die Nachfrage, die Aktienpreise werden entsprechend sinken. Wenn eine Aktie diese Eigenschaft nicht besitzt, dann ist diese Aktie nicht gut. Ich würde in diese Aktie nicht investieren.

Der Moving Average ist auch ein wichtiger Indikator für mich. Ich verwende den MA um den Trend zu identifizieren.

9. Gibt es Aktienkurse, die sich gegenseitig beeinflussen?

IP 5: Wenn eine Firma A in eine andere Firma B investiert, z.B. Firma A kauft die Aktien von Firma B, dann kann die Aktien von Firma B Einfluss auf den Aktienpreis von Firma A haben.
Z.B. viele Banken geben Immobilien-Firmen Darlehen. Wenn die Aktien der Immobilien-Firma steigen, dann werden die Aktien der Banken auch entsprechend steigen.
Wechselkursen können Bereiche von Transport und internationalen Handel beeinflussen.
Ölpreise können auf Autofirmen und Maschinenbaufirmen Einfluss ausüben.

10. Welche anderen (volkswirtschaftlichen) Daten könnten Ihrer Meinung nach mit Aktienkursen korrelieren?

IP 5: Wirtschaftswachstum, Inflation, Zinsen von Banken. GDP, CPI, Firmenereignisse. Wenn ein Sektor Unterstützung von dem Staat hat, kann die Aktie relativ stabil sein, z.B. Umweltschutz, Bildung.

11. Sollte man diese Daten aus Frage 10 als punktuelle Ereignisse (z.B.: Veränderung um 10%) oder als Kurve über die ganze Zeit darstellen?

IP 5: Nicht alle. Firmenereignisse können als punktuelle Ereignisse dargestellt werden.

A2.6 Interview F

1. Welche Task gibt es, um Aktien zu verstehen?

IP 6: Die Periode bzw. der Zeitraum sind wichtig und auch unterschiedlich je nach Investmentstrategie.
Das Ziel der Vergleiche ist das Risiko der Aktienbündel zu minimieren.
Man überprüft Aktien verschiedener Firmen / verschiedene Branchen miteinander.

Vergleich durch Korrelation um Aktienrisiko zu streuen:
- Vergleich mit Index
- Berechnung des Korrelationskoeffizienten

Vergleich mit CAPM (Annahme keine perfekte Korrelation):
Bewertung relativ zum Markt
- beta = 1 wie Markt
- beta < 1 wenier Risiko als Markt
- beta > 1 mehr Risiko als Markt

2. Wie vergleichen Sie zwei oder mehrere Aktienkurse grafisch miteinander? Gibt es Probleme mit dem grafischen Vergleichen? Wenn ja, welche?

IP 6: Ich verwende Liniendiagramme um Daten grafisch zu vergleichen.
Der Vergleich mit dem Dow Jones ist sehr beliebt aber nicht immer richtig (DJIA ist eher repräsentativ für US-Industrie)
Ein Vergleich mit dem S&P 500 ist besser, da allgemeine Aktien enthalten sind.

3. Welche Art von Diagrammen verwenden Sie? (z.B.: Liniendiagramme, Balkendiagramme, Candlestick)

IP 6: Ich verwende Liniendiagramme.

4. Über welchen Zeitraum beobachten Sie üblicherweise die Kurse?

IP 6: Der Zeitraum der Beobachtung ist abhängig von der Investmentstrategie:
Kurzfristig → tägliche Daten
Langfristig □ Trend über längere Zeit suchen, fundamentale Analyse

5. Wie nützlich finden Sie diese Diagramme?

IP 6:--

6. Verwenden Sie interaktive Visualisierungstechniken, z.B. Zoomen, Filtern, Anzeige von Kurswerten anhängig von der Mauszeigerposition? (zum Beispiel http://www.google.com/finance)

IP 6: Interaktive Diagramme sind eigentlich nicht so wichtig für mich um den Trend zu finden oder um die Korrelation zwischen Aktien zu finden.

7. Sind sie mit den interaktiven Möglichkeiten zufrieden?

IP 6:--

8. Welche Daten werden in den Diagrammen angezeigt bzw. welche Daten sind wichtig?

IP 6: Das Marktmodell besagt, daß alle Informationen im Preis enthalten sind, aber der Markt zeigt oft irrationales Verhalten, z.B. Preissturz bei Firmennachrichten. Volumen ist auch wichtig. Ein kleines Volumen bedeutet der Preis nicht wirklich repräsentativ ist. Es können starke Unterschiede zwischen Aktienpreis und dem Wert in der Realität sein.

9. Gibt es Aktienkurse, die sich gegenseitig beeinflussen?

IP 6: Bei einem Merge von zwei Aktiengesellschaften steigt meistens der Aktienpreis der übernommenen Firma.
- Aktien innerhalb eines Industriebereiches.
- Aktien von Konkurrenten.
- Aktien bei Oligopolstrukturen wie Autohersteller oder Banken.

10. Welche anderen (volkswirtschaftlichen) Daten könnten Ihrer Meinung nach mit Aktienkursen korrelieren?

IP 6: MACD, Charttechnken sind eher esoterisch.
Firmendaten, Gewinn, Gewinn / Kursverhältnis, Firmennachrichten.
Volkswirtschaftliche Daten: Produktionsindex, Output, Inflation, Außenhandelsdefizit, Beschäftigung, Arbeitslosenrate.
Aber man muß stark aufpassen weil sich die Werte schnell ändern.

11. Sollte man diese Daten aus Frage 10 als punktuelle Ereignisse (z.B.: Veränderung um 10%) oder als Kurve über die ganze Zeit darstellen?

IP 6: Splits und Dividenden anzeigen ist sicherlich gut.

13. Ist log wichtig? Im Vergleich zu linear, welche Vorteile hat log?
IP 6: Eine logarithmische Skala zeigt die Veränderungsrate in Prozent -> deshalb kann man besser die Steigung sehen.

Appendix B: User Study

B1 Interview Guideline

Fragen zu Linien-, OHLC- und Candlestick Diagramme:

1. Welche der drei Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) bevorzugen Sie? Können Sie die Aussage begründen?

2. Sind die Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) sinnvoll? Gibt es Ihrer Meinung nach Probleme bei den Darstellungen?

3. Ist es Ihrer Meinung nach ein Problem die Aktiekurse untereinander anzuzeigen? Oder würden Sie lieber alle Aktienkurse in einem einzigen Diagramm anzeigen lassen?

4. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

5. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

Fragen zu Indexing Diagramm:

6. Finden Sie diese Darstellungsweise besser oder schlechter als mit den üblichen Diagrammen? Können Sie die Aussage begründen?

7. Finden Sie diese Darstellung besser zum Vergleichen von mehreren Aktienmarktdaten? Gibt es Ihrer Meinung nach Probleme bei der Darstellung?

8. Wie nützlich empfinden Sie das Verändern des Indexing-Punktes beim Vergleichen von Aktienmarktdaten?

9. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

10. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

11. Wie nützlich finden Sie die Legende, deren Werte abhängig von der Mausposition sind?

12. Wie nützlich finden Sie die die Anzeige von volkswirtschaftlichen Daten für eine grafische Analyse von Aktienkursen? Lassen sich diese mit einem Indexing Diagramm besser vergleichen?

13. Welche anderen ökonomischen Daten würden Sie zusätzlich verwenden?

B2 Interviews

B2.1 Interview A

1. Welche der drei Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) bevorzugen Sie? Können Sie die Aussage begründen?

IP 1: Liniendiagramm um den generellen Trend des Aktienkurses zu sehen, Candlestick Diagramme wenn ich mehr Informationen zu dem Aktienkurspreise brauche. Die Cand-

lesticks können die Volatilität des Preises (Differenz höchster/niedrigster und erster/letzter) wiedergeben. Auch Volumen gibt Anzeichen zur Instabilität. Mit den Werten (HLOC und Volumen) kann der richtige exit point ermittelt werden.

2. Sind die Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) sinnvoll? Gibt es Ihrer Meinung nach Probleme bei den Darstellungen?

IP 1: Die Darstellungen entsprechen dem Standard. Eigentlich gibt es keine Probleme.

3. Ist es Ihrer Meinung nach ein Problem die Aktiekurse untereinander anzuzeigen? Oder würden Sie lieber alle Aktienkurse in einem einzigen Diagramm anzeigen lassen?

IP 1: Der Vergleich durch Superimposition ist sicher besser geeignet um mehrere Aktienkurse miteinander zu vergleichen.

4. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 1: Die Zoom Funktion ist gut gemacht. Keine Verbesserung.

5. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 1: Eine logarithmische Skalierung ist im Grunde besser, da prozentuelle Veränderungen grafisch angezeigt werden. Auch Aktienkurse mit stark unterschiedlichen Preisen sind besser zu erkennen.

6. Finden Sie diese Darstellungsweise besser oder schlechter als mit den üblichen Diagrammen? Können Sie die Aussage begründen?

IP 1: Für Vergleiche sicher sehr sinnvoll, da prozentuelle Werte angezeigt werden, was bei Aktien sehr wichtig ist.

7. Finden Sie diese Darstellung besser zum Vergleichen von mehreren Aktienmarktdaten? Gibt es Ihrer Meinung nach Probleme bei der Darstellung?

IP 1: Ja, die Darstellung ist besser. Die prozetuellen Änderungen werden direkt dargestellt. Es it gut, dass sich die Visualisierung der Fentergröße anpasst.

8. Wie nützlich empfinden Sie das Verändern des Indexing-Punktes beim Vergleichen von Aktienmarktdaten?

IP 1: Das Setzen eines Indexpunktes ist sehr nützlich wenn man sehen möchte wie sich ein Kurs verändert hat ab oder bis zu einem gewissen Zeitpunkt. Man kann dadurch Vergleichen wie sich unterschiedlichen Aktienkurse entwickelt haben. Diese Funktion sollte generell verfügbar sein (z.B.: auch in Google Finance)

9. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 1: Gleich wie bei Frage 5.

10. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 1: Die Zoom-Funktion über das Mausrad ist intuitiv. Auch Panning ist intuitiv.

11. Wie nützlich finden Sie die Legende, deren Werte abhängig von der Mausposition sind?

IP 1: Eine sehr nette Funktion, die schnell die Werte anzeigt sobald man den Mauszeiger über den entsprechenden Tag platziert. Sehr nützlich wenn man den Verlauf mittels Zahlen verfolgen möchte.

12. Wie nützlich finden Sie die die Anzeige von volkswirtschaftlichen Daten für eine grafische Analyse von Aktienkursen? Lassen sich diese mit einem Indexing Diagramm besser vergleichen?

IP 1: Es gibt keine allgemeine Regeln / Abhängigkeiten. Aber man kann schon öfters Zusammenhänge zwischen bestimmten Kursen beobachten.

13. Welche anderen ökonomischen Daten würden Sie zusätzlich verwenden?

IP 1: Wechselkurse sind wichtig für internationalen Handel z.B.: Euro - Yuan, Euro - US-$, Ölpreis(e) können sich auf den Gewinn von Transport-Unternehmen auswirken.

B2.2 Interview B

1. Welche der drei Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) bevorzugen Sie? Können Sie die Aussage begründen?

IP 2: Mit Liniendiagrammen kann man die Aktienkursen besser miteinander vergleichen. Für mich sind die täglichen Differenzen von den Preise wie Eröffnungs-, höchster und niederigster Preise nicht so wichtig. Die Liniendiagramme können gut den Preistrend darstellen.

2. Sind die Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) sinnvoll? Gibt es Ihrer Meinung nach Probleme bei den Darstellungen?

IP 2: Ja, klar! Ich bin davon überzeugt, dass die Leute, die sich nur für tägliche Endpreise (close price) interessieren, Liniendiagramme bevorzugen. Die Leute, denen tägliche Schwankungen der Preise wichtig sind, bevorzugen sicher OHLC oder Candlestick Charts.

Probleme OHLC Chart: Die Querstriche (open & close price) kann man nur schlecht erkennen. Die Darstellung des Candlestick Charts ist besser gelungen. Duch die Farbe kann man gut erkennen, ob die Preise des bestimmten Zeitintervalls gestiegen oder gesunken

sind. Die Höhe von dem vertikalen Strich des Candlesticks glyphs zeigt die Unterschiede zwischen Opening und Closing Preise recht gut.

3. Ist es Ihrer Meinung nach ein Problem die Aktiekurse untereinander anzuzeigen? Oder würden Sie lieber alle Aktienkurse in einem einzigen Diagramm anzeigen lassen?

IP 2: Ich bevorzuge die Darstellung in einem Diagram. Dann können die Werte der Aktienkurse besser vergliechen werdeen.

4. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 2: Ja, finde ich sehr nützlich. Diese Zoom Funktion ist gut gelungen! Ich würde nichts daran verbessern.

5. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 2: Die logarithmische Darstellung ist für mich besser. Ich insteressiere mich für den Gewinn, also die Änderung, und nicht für den absoluten Wert. Mit einer logarithmische Skalierung sieht man die Veränderung besser.

6. Finden Sie diese Darstellungsweise besser oder schlechter als mit den üblichen Diagrammen? Können Sie die Aussage begründen?

IP 2: In der Firma, wo ich arbeite, gibt es auch Programme zum Vergleich von Aktienkursen bzw. Aktienfonds. Aber es gibt keine Möglichkeit einen Indexing point zu setzen. Eigentlich gibt es überhaupt keine interaktiven Funktionen.
Mir gefällt die Funktion einen gemeinsamen Indexing point setzen zu können, von dem sich die Aktienkurse weiter entwickeln.

7. Finden Sie diese Darstellung besser zum Vergleichen von mehreren Aktienmarktdaten? Gibt es Ihrer Meinung nach Probleme bei der Darstellung?

IP 2: Ja, finde ich sehr gut. Mir fallen im Moment keine Probleme ein.

8. Wie nützlich empfinden Sie das Verändern des Indexing-Punktes beim Vergleichen von Aktienmarktdaten?

IP 2: Das ist schon sehr nützlich. Damit kann man sehr eindeutig den vergleich von mehreren Aktien bzw. Aktienfonds darstellen.

9. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 2: Ja, ich bevorzuge die logarithmische Darstellung. Dadurch kann man über die Steigung auf die prozentuale Veränderung schließen.

10. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 2: Ja, ist sehr nützlich. Ich denke die Funktion ist gut genug.

11. Wie nützlich finden Sie die Legende, deren Werte abhängig von der Mausposition sind?

IP 2: Finde ich top! Wenn man die einzelne Werte wissen möchte oder tägliche Werte vergleichen möchte, kann man mittels der Bewegung der Mause die Werte ansehen.

12. Wie nützlich finden Sie die die Anzeige von volkswirtschaftlichen Daten für eine grafische Analyse von Aktienkursen? Lassen sich diese mit einem Indexing Diagramm besser vergleichen?

IP 2: Ja, das kann nützlich sein. Weil man manchmal schließen kann, welche Auswirkung die volkswirtschaftliche Daten auf bestimmte Aktienkurse haben.

13. Welche anderen ökonomischen Daten würden Sie zusätzlich verwenden?

IP 2: Rohstoffepreise haben Auswirkungen auf die Industrie bzw Produzenten.

B2.3 Interview C

1. Welche der drei Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) bevorzugen Sie? Können Sie die Aussage begründen?

IP 3: Ich bevorzuge OHLC und Candlestick Chart，weil diese mehr Preisinformationen beinhalten (erster, höchster, niedrigster und letzter Preis). Mit solchen Diagrammen kann ich besser Patterns finden. Mit Hilfe der gefundenen Patterns kann ich besser Entscheidungen zum Kauf und Verkauf treffen.

2. Sind die Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) sinnvoll? Gibt es Ihrer Meinung nach Probleme bei den Darstellungen?

IP 3: Das Liniendiagramm finde ich sehr nützlich, wenn ich den Trend des Aktienkurses erkennen möchte. Für mehr konkrete Informationen sind OHLC- und Candlestick Diagramme hilfreicher. Die Darstellungen sind keine großen Probleme, wenn man die Bedeutung kennt und sich daran gewöhnt.
Ein Problem ist die Beschränkung auf nur einen 30-Tage Moving Average. Es sollten auch 5-Tage, 10-Tage, 20-Tage verfügbar sein.

3. Ist es Ihrer Meinung nach ein Problem die Aktiekurse untereinander anzuzeigen? Oder würden Sie lieber alle Aktienkurse in einem einzigen Diagramm anzeigen lassen?

IP 3: Das Vergleichen von Aktienkursen mit Superimposition ist aber sicher übersichtlicher.
Das Problem von einer Übereinanderlegung (Superimposition) liegt darin, ob die Aktienkurse nach Umrechnung noch in einem einzigen Diagramm vergleichbar und erkennbar sind. Zum Beispiel wenn die Aktienkurse verschiedene Einheiten haben (US-$, € Yuan,

etc.) oder zu große Unterschiede zwischen den Aktienpreisen existieren. In solche Situationen würde ich nicht Superimposition verwenden, sondern eher Juxtaposition.

Ich finde es toll, dass es in dem Prototyp auch OHLC oder Candlestick Charts von verschiedenen Aktienkursen mit Juxtaposition vergleicht werden können. Oft gibt es keine Möglichkeit Aktienkursen in Form von OHLC und Candlestick Charts miteinander zu vergleichen. Deshalb muß ich jedes Mal mit Photoshop (ein Grafikeditor) die Screenshots der Charts selbst untereinander platzieren. Damit kann ich OHLC oder Candlestick Charts miteinander vergleichen.

4. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 3: Die Zoom-Funktion ist sehr nützlich für die Analyse innerhalb eines bestimmten Zeitraumes.

5. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 3: Die logarithmische Darstellung ist vorteilhaft, wenn man die Änderungsraten (mit großer Differenz) von Aktienkursen vergleichen möchte. Falls die Aktienkurse aber nicht stark voneinander variieren, bevorzuge ich die lineare Darstellung.

6. Finden Sie diese Darstellungsweise besser oder schlechter als mit den üblichen Diagrammen? Können Sie die Aussage begründen?

IP 3: Die Darstellung ist besser, da die zusätzliche Änderungsrate angezeigt wird.

7. Finden Sie diese Darstellung besser zum Vergleichen von mehreren Aktienmarktdaten? Gibt es Ihrer Meinung nach Probleme bei der Darstellung?

IP 3: Ja die Darstellung ist besser, da man sowohl die Aktienkurse als auch die dazugehörige Änderungsrate vergleichen kann.

8. Wie nützlich empfinden Sie das Verändern des Indexing-Punktes beim Vergleichen von Aktienmarktdaten?

IP 3: Ja, sehr nützlich.

9. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 3: Siehe 5.

10. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 3: Ja, die Zoom-Funktion ist sehr nützlich. Egal welche Weise, wichtig ist es, daß der angezeigte Zeitraum sowohl vergrößert als auch verkleinert werden kann.

11. Wie nützlich finden Sie die Legende, deren Werte abhängig von der Mausposition sind?

IP 3: Die Darstellung ist sehr interaktiv, so dass ich die interessanten Werte sofort ablesen kann.

12. Wie nützlich finden Sie die die Anzeige von volkswirtschaftlichen Daten für eine grafische Analyse von Aktienkursen? Lassen sich diese mit einem Indexing Diagramm besser vergleichen?

IP 3: Durch den Vergleich kann ich den Zusammenhang zwischen den volkswirtschaftlichen Daten und Aktienkursen erkennen. Man kann herausfinden, ob und welche volkswirtschaftlichen Daten einen Einfluss auf den Aktienmarkt haben.

13. Welche anderen ökonomischen Daten würden Sie zusätzlich verwenden?

IP 3: Internationale Future Preise wie z.B. Rohöl.

B2.4 Interview D

1. Welche der drei Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) bevorzugen Sie? Können Sie die Aussage begründen?

IP 4: Ich bevorzuge OHLC und Candlestick Charts, weil sie mehr Preisinformationen (opening, closing, highest, lowest prices) anzeigen. Damit kann ich sehen, ob die Preise für die jeweiligen Zeitperioden gestiegen oder gesunken sind.

2. Sind die Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) sinnvoll? Gibt es Ihrer Meinung nach Probleme bei den Darstellungen?

IP 4: Das Liniendiagramm ist für die langfristige Analyse geeignet. Damit kann man den Trend sehen. Für kurzfristige Analyse ist entweder OHLC oder Candlestick Charts gut.

3. Ist es Ihrer Meinung nach ein Problem die Aktiekurse untereinander anzuzeigen? Oder würden Sie lieber alle Aktienkurse in einem einzigen Diagramm anzeigen lassen?

IP 4: Ich bevorzuge es die Aktienkursen in einem einzigen Diagramm zu vergleichen, da es einfacher und bequemer für mich ist. Man kann damit die Preise direkt vergleichen. Wenn die Aktienkurse untereinander angezeigt werden, muß man die Y-Achse betrachten und mit den anderen Y-Achsen vergleichen. Zum Beispiel auf welchem Wert die Preise liegen, danach kann man die Preise visuell vergleichen.

4. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 4: Ja, die Zoom-Funktion ist sehr nützlich. Es wäre besser, wenn das genaue Datum, also von wann bis wann, auf der linken und rechten Seite des markiertem Bereich angezeigt werden könnte.

5. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 4: Wenn man die Schwankungen oder die prozentuale Veränderungen von Aktienkursen miteinander vergleichen möchte, ist eine logarithmische Darstellung besser.

6. Finden Sie diese Darstellungsweise besser oder schlechter als mit den üblichen Diagrammen? Können Sie die Aussage begründen?

IP 4: Diese Darstellungsweise ist für ein Vergleichen von prozentualen Veränderungen geeignet. Aber es ist nicht dafür geeignet, absolute Preise von Aktien zu bestimmten Tagen zu vergleichen.
Meiner Meinung nach kann man nicht einfach sagen, dass diese Darstellung besser oder schlechter als andere ist. Jede Darstellung hat seine Vorteile. Es gibt eigentlich kein Diagramm, mit dem alle Bedürfnisse befriedigt werden können.

7. Finden Sie diese Darstellung besser zum Vergleichen von mehreren Aktienmarktdaten? Gibt es Ihrer Meinung nach Probleme bei der Darstellung?

IP 4: Es kommt darauf an, was man vergleichen möchte. Wenn man nur die prozentualen Veränderungen vergleichen möchte, ist diese Darstellung gut. Wenn man die absolute Preise eines bestimmten Tages vergleichen möchte, bevorzuge ich normale Liniendiagramme.

8. Wie nützlich empfinden Sie das Verändern des Indexing-Punktes beim Vergleichen von Aktienmarktdaten?

IP 4: Es ist sehr nützlich und wichtig, den Indexing-Punkt ändern zu können, damit kann man die prozentualen Veränderungen von unterschiedlichen Zeitpunkten vergleichen.

9. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 4: Siehe Frage 5.

10. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 2: Ja, es ist nützlich. Aber die vorige Zoom Funktion ist besser und bequemer. Zoom mit dem Mousewheel ist sehr ungenau, also der Zeitbereich kann nicht präzise eingegeben werden. Ich mag die Zoomfunktion über Time-Slider ähnlich wie bei Google Finance. Es wird eine Übersicht des ganzen Zeitbereiches unter dem Diagramm dargestellt. Man kann durch den Slider einen bestimmten Bereich auswählen, der danach in dem Diagramm angezeigt wird.

11. Wie nützlich finden Sie die Legende, deren Werte abhängig von der Mausposition sind?

IP 4: Sehr gut und einfach zu verwenden. Man kann die genauen Werte der Aktienpreise lesen, wenn man will.

Es wäre besser, wenn man die Position der Legende mittels drag and drop ändern könnte, da die Legende manchmal einen Teil des Diagramms überdeckt.

12. Wie nützlich finden Sie die die Anzeige von volkswirtschaftlichen Daten für eine grafische Analyse von Aktienkursen? Lassen sich diese mit einem Indexing Diagramm besser vergleichen?

IP 4: Es gibt viele volkswirtschaftliche Faktoren, die Einflüsse auf den Aktienpreis haben. Viele Leute ändern ihre Investment-Entscheidungen wenn sich z.B. die Leitzinsen ändern. Wenn die Zinsen hoch sind, sparen die Leute gerne ihr Geld in der Bank, weil es weniger riskant ist. Wenn die Zinsen niedrig sind, werden viele Leute ihr Geld in Aktien investieren.

Beim Vergleichen von Aktienkursen und volkswirtschaftlichen Daten muß man aufpassen. Es macht keinen Sinn, wenn man die volkswirtschaftlichen Daten mit einzelnen Aktienkursen vergleicht. Besser ist ein Vergleich mit Indices oder mit einer Gruppe von Aktien, die derselben Industrie angehören. Dann ist der Vergleichen mehr aussagekräftig.

13. Welche anderen ökonomischen Daten würden Sie zusätzlich verwenden?

IP 4: BIP bzw. GDP (gross domestic product) und Wechselkurse. Die Zinsen und Wechselkurse können sich auch gegenseitige beeinflussen.

B2.5 Interview E

1. Welche der drei Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) bevorzugen Sie? Können Sie die Aussage begründen?

IP 5: Ich bevorzuge Candlestick Charts. Im Vergleich zu Liniendiagrammen kann das Candlestick Chart mehr Preisinformationen (open, high, low, close prices) anzeigen. Im Vergleich zu OHLC Chart ist das Candlestick Chart visuell einfacher zu verstehen. Candlestick gylphs verwenden die Farben Rot und Grün um Preistrends zu unterscheiden. Also ob die Preise für die Zeitperiode gestiegen oder gesunken sind.

OHLC Chart verwendet horizontale Striche um den ersten und letzten Preise anzuzeigen. Die Methode der Candlestick Glyphen dies mittels Farbe anzuzeigen gefällt mir besser als beim OHLC Glyph.

2. Sind die Darstellungen (Liniendiagramm, OHLC- und Candlestick Diagramm) sinnvoll? Gibt es Ihrer Meinung nach Probleme bei den Darstellungen?

IP 5: Ja. OHLC und Candlestick charts sind für kurzfristige Investment-Strategien geeignet. Liniendiagramme sind für langfristige Strategie besser. Die horizontalen Striche der

OHLC Glyphen sind zu klein, man sieht die Linien nicht so gut. Es wäre gut, wenn die horizontalen Linien stärker gezeichnet werden.

3. Ist es Ihrer Meinung nach ein Problem die Aktiekurse untereinander anzuzeigen? Oder würden Sie lieber alle Aktienkurse in einem einzigen Diagramm anzeigen lassen?

IP 5: Ich bevorzuge Liniendiagramme von mehreren Aktienkursen in einem Diagramm zu vergleichen. Aber wenn die Preisunterschiede der Aktien zu groß sind, sind die Aktienkurse sehr flach. In diesem Fall würde ich einen Vergleich mittels Nebeneinanderlegen (Juxtaposition) verwenden.
Wenn ich OHLC oder Candlestick Charts miteinander vergleichen möchte, bevorzuge ich die Diagramme untereinander anzuzeigen, damit es keine Überlappungen der Glyphen gibt.
Es wäre besser, wenn ich die Reihenfolge der Diagramme ändern kann. Ich möchte die Diagramme an eine beliebige Position schieben, damit ich die gewünschten Diagramme besser mit einander vergleichen kann.

4. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 5: Die Zoomfunktion ist sehr nützlich und wichtig. Dadurch ist das Diagramm mehr interaktiv.

5. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 5: Ich bevorzuge die logarithmische Darstellung, da ich sowohl die Preise eines bestimmten Tages vergleichen kann als auch die prozentualen Veränderungen vergleichen kann.

6. Finden Sie diese Darstellungsweise besser oder schlechter als mit den üblichen Diagrammen? Können Sie die Aussage begründen?

IP 5: Diese Darstellung ist ganz gut für das Vergleichen von prozentualen Veränderungen geeignet. Die Darstellung zeigt an, welche Aktie eine höhere prozentuale Steigung oder Verlust hat. Auch mit linearer Skalierung kann man nicht so gut die prozentualen Veränderungen vergleichen.

7. Finden Sie diese Darstellung besser zum Vergleichen von mehreren Aktienmarktdaten? Gibt es Ihrer Meinung nach Probleme bei der Darstellung?

IP 5: Diese Darstellung ist auch gut für das Vergleichen von den Aktienkursen, die eigentlich unterschiedliche Währungen haben. Man kann mit dieser Darstellung Aktienkursen mit anderen volkswirtschaftlichen Zeitreihen vergleichen.
Diese Darstellung ist allerdings nicht so gut geeignet, um die (absoluten) Aktienpreise von bestimmten Tagen miteinander zu vergleichen.

8. Wie nützlich empfinden Sie das Verändern des Indexing-Punktes beim Vergleichen von Aktienmarktdaten?

IP 5: Sehr nützlich, so kann ich jeden Zeitpunkt als Basis setzen. Der Basis-Zeitpunkt ist auch sehr wichtig für den Vergleich. Ich finde es sinnvoll, die Aktienkursen basierend auf unterschiedlichen Start-Zeitpunkten zu vergleichen.

9. Bevorzugen Sie eine lineare oder eine logarithmische Darstellung der y-Achse bei einem Vergleich von Aktienmarktdaten? Können Sie die Aussage begründen?

IP 5: Siehe Frage 5.

10. Finden Sie die Zooming-Funktion nützlich? Was würden Sie daran verbessern?

IP 5: Die Funktion ist sehr nützlich. Auch das Verschieben (panning) nach links oder nach rechts ist nützlich. Das automatische Anpassen von Diagrammen zur Größe der Appliaktion finde ich gut.

11. Wie nützlich finden Sie die Legende, deren Werte abhängig von der Mausposition sind?

IP 5: Die Legende ist sehr interaktiv und wichtig. Ich bin damit sehr zufrieden. Aber es wäre besser, wenn die Daten, in der Nähe des Mauscursors, hervorgehoben werden. Zum Beispiel dass eine horizontale Linie durch den aktuellen Wert gezeichnet wird. Also ähnlich wie ein Crosshair durch den aktuellen Punkt.

12. Wie nützlich finden Sie die die Anzeige von volkswirtschaftlichen Daten für eine grafische Analyse von Aktienkursen? Lassen sich diese mit einem Indexing Diagramm besser vergleichen?

IP 5: Volkswirtschaftlichen Daten können Einfluß auf Aktienkurse haben. Aber es ist sehr schwer diesen Einfluß zwischen volkswirtschaftlichen Daten und Aktien präzise zu definieren.
Durch Vergleichen von volkswirtschaftliche Daten und Aktienkursen, kann man davon erkennen, welche Auswirkung die volkswirtschaftlichen Daten auf Aktien und umgekehrt haben. Die Auswirkungen sind meist nicht sofort bemerkbar. Es können Wochen zwischen einem auslösenden Ereignis wie einer Finanzkrise und den Auswirkungen auf die realen Wirtschaft vergehen. Einfache Beobachtungen und Vergleiche auf Korrelationen sind deshalb nur sehr begrenzt wirksam. Möglicherweise helfen spezielle ökonomische bzw. mathematische Modelle um die Auswirkungen besser einzuschätzen zu können.

13. Welche anderen ökonomischen Daten würden Sie zusätzlich verwenden?

IP 5: Das BIP bzw. GDP beschreibt den Trend der gesamten Wirtschaft innerhalb eines Jahresquartals. Es kann also dazu dienen um einen Trend der realen Wirtschaft zu entdecken.

Ein Abfall der Aktienmärkte führt auch manchmal zu einer höheren Arbeitslosenrate, welches wiederum einen negativen Effekt auf die gesamte Wirtschat hat. Der Konsum wird verringert und die Leute sparen eher. Das sind Anzeichen einer Deflation.