ThermalPlot: Visualizing Multi-Attribute Time-Series Data Using a Thermal Metaphor

Holger Stitz* Johannes Kepler University Linz

Samuel Gratzl† Johannes Kepler University Linz

Wolfgang Aigner‡ St. Poelten University of Applied Sciences

Marc Streit§ Johannes Kepler University Linz

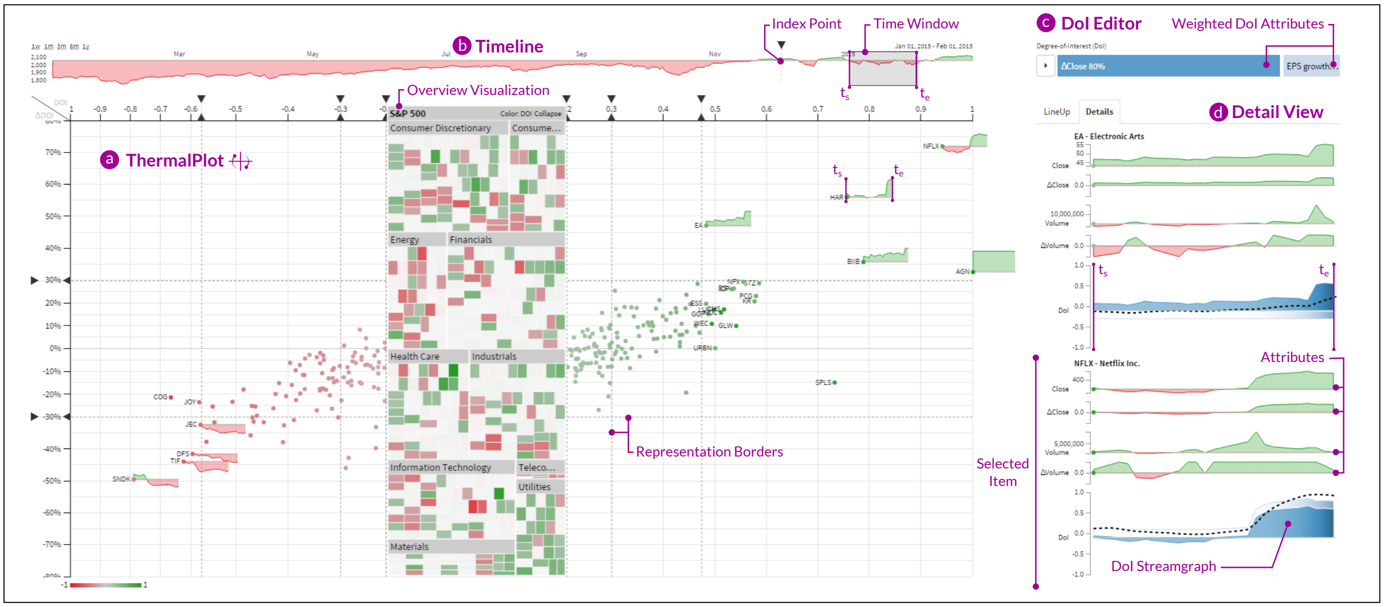

Figure 1: *The ThermalPlot technique (a) integrated in the exploration environment for multi-attribute time-series data showing the development of companies listed in the S&P 500 index within a user-specified time window (b). Item positions in the plot are based on the selected index point and the weighted DoI attributes configured via the DoI editor (c). The detail view (d) shows the development of the composed DoI over time as streamgraphs and the line charts of single attributes for selected items.*

Abstract

Multi-attribute time-series data plays a vital role in many different domains. An important task when making sense of such data is to provide users with an overview to identify items that show an interesting development over time. However, this is not well supported by existing visualization techniques. To address this issue, we present *ThermalPlot*, a visualization technique that summarizes complex combinations of multiple attributes over time using an item's position, the most salient visual variable. More precisely, the x-position in the *ThermalPlot* is based on a user-defined degree-of-interest (DoI) function that combines multiple attributes over time. The y-position is determined by the relative change in the DoI value (ΔDoI) within a user-specified time window. Animating this mapping via a moving time window gives rise to circular movements of items over time—as in thermal systems. To help the user to identify important items that match user-defined temporal patterns and to increase the technique's scalability, we adapt the items' level of detail based on the DoI value. We demonstrate the effectiveness of our technique in a stock market usage scenario.

*e-mail: holger.stitz@jku.at
†e-mail: samuel.gratzl@jku.at
‡e-mail: wolfgang.aigner@fhstp.ac.at
§e-mail: marc.streit@jku.at

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1 Introduction

Understanding temporal developments of multi-attribute data is an essential task in many domains, such as stock market analysis, sensor networks, and biology. The complexity increases significantly when scenarios comprise a collection of items, where each item comes with a set of multiple attributes that change over time. An important task when making sense of such data is to provide users with an overview for identifying items that show an interesting temporal development. In this poster, we present *ThermalPlot*, a visualization technique that gives analysts an overview of a collection of items by encoding time-dependent changes in attributes into the item position, which is known to be the strongest visual variable for encoding quantitative data. The item position is based on a modular degree-of-interest (DoI) function which combines multiple attributes with adjustable weight, allowing analysts to detect outliers, trends and patterns.

2 Related Work

Exploring complex real-world phenomena almost always requires taking into account a number of interrelated attributes along with their changes over time. To effectively address this goal, it is necessary to tackle two challenges: The first challenge lies in the **integration and comparison of multiple heterogeneous attributes for a collection of items**, which can be addressed by mapping time to time (aka animation, e.g., [5]), mapping time to space to detect seasonal patterns and trends (e.g., [3]) or showing them as small

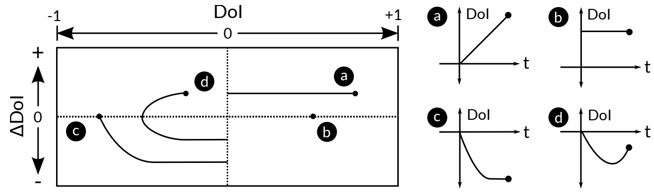

Figure 2: *The DoI value is mapped to the x-axis and the ΔDoI to the y-axis. DoI values that change over time result in distinctive positions and trajectories of items in the ThermalPlot space.*

multiples (e.g., [4]). However, such approaches do not scale well to multiple attributes, a large set of items, or long time-series and only work in combination with automated detection and guidance mechanisms that point users to relevant parts. The second challenge is the **extraction of temporal dynamics on multiple levels**, which can be addressed by superimposing multiple curves in a line chart, by stacking multiple line or horizon charts [2], or by using other pixel-based techniques [1]. However, these solutions often do not work for making comparisons in both directions simultaneously. In summary, we could not identify an existing technique that allows users to address both challenges for a large collection of multi-attribute items.

3 *ThermalPlot* Visualization Concept

The fundamental idea underlying *ThermalPlot* is simple but effective: we map a user-specified degree-of-interest (DoI) value on the x-axis and the change in the DoI value (ΔDoI) on the y-axis, as illustrated in Figure 2. The DoI value is a weighted combination of one or multiple attributes over time. Depending on the usage scenario, the analyst defines a DoI function that results in high DoI values for items of interest. The ΔDoI is determined by the DoI change between the start (t_s) and end (t_e) of a user-defined time window (see Figure 1(b)). The items are then placed in the plot according to their DoI and ΔDoI values. This mapping results in a visualization where users can derive an aggregated summary of the items' developments over time from their positions in the plot. Another consequence of this mapping is the thermal-like movements of items within the plot over time. The *ThermalPlot* concept is particularly powerful in two basic use cases: (1) showing a static snapshot that summarizes the temporal development of items in a given time window, and (2) presenting the status of streaming data, where item positions are slowly updated when new data comes in.

Clutter Reduction Strategies As in any scatterplot representation, a high density of marks in a certain region of the plot can result in occlusion problems and visual clutter. To increase the scalability of the *ThermalPlot* technique regarding the number of items, we apply a two-fold strategy that combines semantic zooming with optional orthogonal stretching of scales. **Representation borders**, that cause the item's representation to change when crossed can be defined for both axes, resulting in a grid in which the level of detail can be specified for each grid cell.What information the various levels of detail show depends on the usage scenario (e.g., L1: colored mark, L2: L1 + label, L3: L2 + line chart, L4: L3 + trajectory). Items with a zero or low DoI value are by definition of no or low interest to the user. We optionally use the space to visualize all items as marks inside an **embedded overview visualization** that provides a meaningful structure and supports the user in locating items (see treemap in Figure 1). In addition to semantic zooming, we use orthogonal stretching where parts of the scale can be stretched or compressed either pre-defined statically for a specific setup or dynamically by the user. Users can either move a representation border or distorting the space by dragging the small triangles next to the plot, as illustrated in Figure 1.

Support views To put the *ThermalPlot* method to practical use, a couple of support visualizations are required. As illustrated in Figure 1, the overall multi-coordinated view setup consists of four linked components: (a) the *ThermalPlot* as the heart of our system, (b) the **timeline** showing the full time range for which data is available lets the user set an index point t_{index} and a time window $t_s - t_e$ that specifies the data which serves as an input to *ThermalPlot*, (c) the **DoI editor** as an interface for composing the DoI function by means of combining and weighting multiple attributes, and (d) the **detail view** presenting the development of attributes over time for the selected items.

4 Use Case

We demonstrate the effectiveness by means of a stock market scenario. A financial consultant, who invests his private savings in stocks, checks his personal portfolio once or twice a week with the goal to find underrated companies and make informed investment decisions. He sets a time window to include all data from the last month of trading (see Figure 1(b)). For the DoI computation the private investor chooses a combination of the dynamic *closing price* (80%) and the static *earnings per share (EPS) growth* (20%) (see Figure 1(c)). The *ThermalPlot* shown in Figure 1(a) gives the investor an effective overview by summarizing the recent developments on the market. Companies with a considerable positive development since the start of the year appear on the right side of the treemap, whereas companies with a negative development are positioned on the left. Each quadrant has a distinct meaning. The lower right quadrant, for instance, contains companies that show a positive development since the beginning of the year but have a recent negative trend over the last days.

5 Conclusion

In this poster we presented *ThermalPlot*, a scalable visualization technique for exploring multi-attribute time-series data. We use the position—the strongest visual variable—to encode item importance according to the DoI value in the horizontal direction and according to the change in DoI value (ΔDoI) in the vertical direction. This mapping allows users to see effectively the development of attributes over time at a glance.

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