

Novel Interaction Techniques for Visual Comparison

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ABSTRACT

Comparison is an important task when visually exploring and analyzing data. We devised interaction techniques that assist in conducting comparison tasks for table-based and matrix-based visual representations. The basic idea is to allow users to dynamically create snapshots of parts of the visual representation. For the comparison of such snapshots, the user can (1) flexibly arrange them on the screen, (2) temporarily fade them out, or (3) temporarily fold them away. These techniques aim to enable users to easily contrast the data depicted in a snapshot with data in the base visualization or in other snapshots. Additional visual cues are provided to further assist the user in finding dis/similar parts in the data.

Keywords: Visual comparison, interaction techniques, table visualization, matrix visualization.

1 INTRODUCTION

Visualization techniques support users in a variety of data exploration and analysis tasks, of which visual comparison takes a central role. By comparing different parts of the data in detail, users can confirm, fine-tune, or reject initial hypotheses, and thus can gain a better understanding of the data. Existing solutions support comparison tasks mainly by visual means, including special visual encodings (e.g., visualization of differences) and special visual layouts (e.g., side-by-side views). Because visual comparison is a dynamic process where users repeatedly identify subjects for comparison and contrast them with each other, it is also necessary to provide dedicated interaction support. In our work, we expand the user's toolbox by interaction techniques for visual comparison of table-based and matrix-based visualizations. In particular, we address the following aspects.

First, users must be enabled to flexibly define what the subjects of the comparison will be. While we can assume that the visualization already supports the user in spotting interesting candidates, it makes sense to provide additional visual cues to aid in the search. Secondly, an obvious problem is that the selected subjects might be located in different parts of the screen or even might not be visible at the same time (e.g., when comparing the first and the last rows of a scrollable table visualization). This can severely hamper the comparison, because the eyes have to travel larger distances and the user has to temporarily memorize parts of the visual representation. Therefore, the subjects to be compared must be dynamically relocated to make the comparison easily achievable. However, even with a side-by-side layout the comparison might be difficult because the eyes still have to move from one side to the other side. To minimize the eye movement, the subjects ideally would have to be located directly on top of each other. This is related to the real world where people may compare sheets of transparent paper by holding them against the light. What works well in the real world is more difficult in the virtual world, because the occlusion of the subjects can be disadvantageous. Therefore, appropriate support is needed to interactively gauge the comparison process in between the extremes: much eye movement vs. no eye movement and no occlusion vs. full occlusion.

We present first results of our ongoing efforts to address the aforementioned aspects. Our focus is on presenting interactive solutions, deliberately leaving usability questions for later detailed evaluation. The presented techniques are inspired by real world interaction as people may perform it when comparing printed paper. We are mainly interested in three natural ways of comparison where the paper is (1) laid out side-by-side, (2) stacked and held against the light, and (3) stacked and temporarily folded away. Our goal is to create interaction techniques for information visualization that resemble these natural ways of comparison as closely as possible. We hypothesize that by achieving this goal we can significantly ease comparison tasks.

2 APPROACH

Our approach has been designed with table-based and matrix-based visualizations in mind. Table-based techniques such as the Table Lens or heat maps are commonplace in many applications. Matrix-based techniques are particularly related to graph visualization. Generally, table-based and matrix-based visualizations have much in common. They are constructed from rows and columns and the encoding of data values in the individual cells can be realized in various ways, including color coding, bars, or glyphs. The commonality of table-based and matrix-based visualizations allows us to develop our approach for both worlds.

The basis for our interaction techniques is a visualization that shows the entire data set as a large table or matrix in the main view. The base visualization resides in a zoomable viewing space to facilitate overview and detail exploration.

Subjects of Comparison The first step before any comparison is to define the subjects to be compared. For table/matrix-based visualizations, the subjects can be individual cells, rows, and columns as well as arbitrary sub-tables/matrices. Usually, it is the user's task to mentally identify and shape subjects of interest and to keep the extracted information in mind throughout the course of the comparison, which can be quite difficult.

We aim to ease this step by providing techniques for dynamically defining what to compare and for making the defined subjects explicit. To this end, at any time during the exploration of the data, if users spot something interesting they can create a so-called snapshot, which corresponds to an arbitrary sub-table/matrix. The snapshot creation is based on traditional click and drag interaction. Once created, a snapshot is detached from the base visualization and shown as a separate table/matrix in the viewing space. To maintain an overview of the created snapshots, we collect them in a thumbnails view. This relieves the user of keeping comparison subjects in mind. Clicking in the thumbnails view triggers an animation in the main view to automatically center the selected snapshot. This allows users to switch between snapshots easily.

The defined snapshots are subsequently used to perform the actual comparison. A snapshot can be compared with the base visualization or with another snapshot by using the three interaction techniques illustrated in Figure 1(a) and described next.

Side-By-Side Comparison Traditionally, visual comparison is supported by providing separate views that show the information to be compared in a fixed side-by-side layout. Our solution is different in that we allow the users to flexibly select and arrange the snapshots for side-by-side comparison as if they were shifting paper

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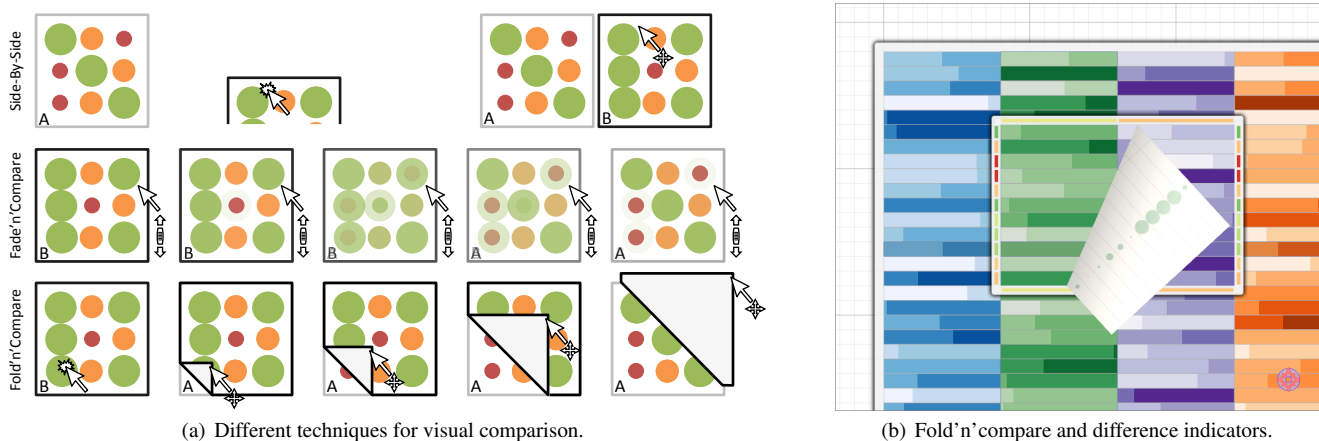


Figure 1: Interaction techniques for comparing table and matrix visualizations.

on a table. The snapshots can be freely moved in the viewing space by simple drag and drop interaction. This way, users can align snapshots dynamically depending on the extents of the snapshots and on the data shown in the snapshots.

Fade'n'Compare As with natural comparison of paper, we also allow users to place the snapshots exactly on top of each other. However, the resulting occlusion renders any comparison impossible. Therefore, the users need some tool to *look through* the snapshots. One way to achieve this is to temporally fade out a snapshot to momentarily reveal otherwise occluded information. This is related to the natural behavior of holding two sheets of paper against the light. We support this interaction by simple mouse wheel rotation. Using forward and backward rotation, the user can adjust the alpha-blending to a degree that suits the comparison task.

Fold'n'Compare Flipping a page back and forth to reveal information shown on a different page is another natural way of interaction. This inspired us to develop an alternative interaction technique for comparing subjects that are aligned on top of each other. We propose to temporarily fold away snapshots to uncover occluded information. For this purpose, snapshots can be peeled off as if they were virtual paper by simple click and drag interaction (see Figure 1(b)). A nice side effect is that the back side of the virtual paper can be used to display additional information such as differences or an alternative visual encoding.

Virtual folding has already been used successfully for other interaction tasks [1], but it can be considered novel in the context of visual comparison.

Additional Visual Cues It makes sense to further support visual comparison by additional visual cues. We provide such support in the form of difference indicators that can optionally be attached to the borders of snapshots (see Figure 1(b)). The indicators visualize the difference between the data values shown in the snapshot and the data values in the base visualization that are occluded by the snapshot. It is possible to show one overall aggregated difference or individually aggregated differences for rows and columns. While moving a snapshot across the base visualization, the indicators are updated automatically. This helps users in spotting parts in the data that are worth comparing in detail.

Discussion The presented techniques have different strengths and weaknesses. Side-by-side comparison is useful for smaller snapshots with only a few rows and columns. For larger snapshots it becomes more and more difficult to keep track of the cells to be compared because the eyes have to travel larger distances. In such cases, placing snapshots on top of each other might be the better solution because they eye movement is bounded.

Moreover, it depends on the visual encoding which technique to apply to *look through* the snapshots. Our experience is that data values depicted via the visual variables size, length, and position can be compared quite well with *fade'n'compare*. However, color-coded visual representations are more difficult to analyze due to the adverse effects of unintended color blending. This is where *fold'n'compare* comes into play. Folding has the advantage that no unintended color blending occurs and that the back side of the folded snapshot can be used to further assist in the comparison. On the other hand, folding back and forth requires repeated mouse movements, which users may experience as tedious.

3 SUMMARY AND FUTURE WORK

We have presented an approach that supports visual comparison for table-based and matrix-based visualizations. Our solution includes techniques for dynamically defining sub-tables and sub-matrices as snapshots for later comparison, for arranging snapshots freely in the viewing space to facilitate side-by-side comparison, and the two techniques *fade'n'compare* and *fold'n'compare* for comparing snapshots aligned on top of each other. All techniques are closely related to real world comparison, which potentially makes the proposed techniques easy to learn and use. For the future, we plan to conduct an extensive user study to evaluate the usefulness of our approach for tables and matrices of different size, for different visual encodings, and for different comparison tasks.

We also have in mind further improvements. It might be useful to have a mode that automatically animates back and forth the fading and folding upon user request. Moreover, tools for automatically adjusting the sizes of a set of snapshots could be helpful. By integrating the interaction gestures described in [1] we could enable users to fold multiple snapshots. We also plan to experiment with novel interaction and display devices such as multi-touch interaction on table-top displays or natural gestures in large display environments.

Particularly for large tables or matrices it is sensible to strengthen the analytical back-end of our concept. We could for example pre-compute good candidates for comparison. Knowing where potential candidates are located in the data would allow us to use force-directed methods or snapping mechanisms to automatically attract matching subjects as users explore the viewing space.

Finally, we are interested in applying and extending our techniques beyond table-based and matrix-based visualizations.

REFERENCES

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