Table2Table: Comprehensible Transitions from Data to Visualizations

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Abstract

We propose Table2Table, a framework introducing a set of unified rules for smoothly animated transitions from raw data to visualizations, which can help users understand the visualization pipeline underlying a chart. Visualizations and transitions conform to tabular layouts to benefit from their simplicity and familiarity. We performed an elicitation study to collect transitions designed by participants with visualization experience. A prototype system is implemented to demonstrate meaningful transitions. A user study shows that our methods can generate expressive visualizations and have positive effects on understanding the pipeline.

Index Terms: Visualization Transition, Data Transformation, Visualization Understanding

1 Introduction

Visualization is one of the most effective techniques for data exploration, analysis, and demonstration, allowing users to gain insight into data by leveraging their natural perceptual abilities. When visualizations are used to show data to an audience, it is critical that the audience understand the encoding of data attributes in the visual channels and the data transformation process in the visualization pipeline. Previous works have shown how animated transitions can be used to help users understand specific visualizations. Ruchikachorn and Mueller [2] transformed familiar visualizations to unfamiliar ones. Pu et al. [1] designed transitions for each data operation.

We propose a framework of unified rules for transitions from raw data to visualizations. We simplify things by limiting the style of visualizations to *tabular forms*. By this, we mean that each component in the final visualization, as well as in the intermediate transition stages, conforms to orthogonal rows and columns. Tables are widely used for storing, editing, and exploring data, and users are familiar with navigation, selection, and operations within tables such as filtering, sorting, inserting, deleting, moving, transposing, merging, and dividing, providing a rich vocabulary for designing meaningful animation stages that are easily understood. We have implemented a prototype system demonstrating animated transitions from data table to visualizations including bar chart, stack bar chart, heatmap, strip plot, and indent pixel tree. We also conduct a user study to validate the effectiveness of the proposed transition framework.

2 Transition Framework

We conducted an elicitation study asking participants to design transitions for several types of visualizations. We then summarized the designs into an operation framework. There are three categories of operations including the data transformation, item encoding, and layout method. The data transformation operations include *count*, *sum*, *mean*, *normalization*, *sort* and *binning*. The item encoding operations consist of *length encoding* and *color encoding* for table cells, and *size encoding* and *position encoding* for embedded marks. The layout operations involve *grouping*, *rotation*, and *alignment*. We designed transitions for each operation. Some of the operations are illustrated in Fig. 1.

With the framework, we can generate transition paths from a data table to the final visualization. We designed a grammar to represent intermediate transition steps. The visualizations are rendered by considering each data row as a unit and calculating the layout of items recursively.

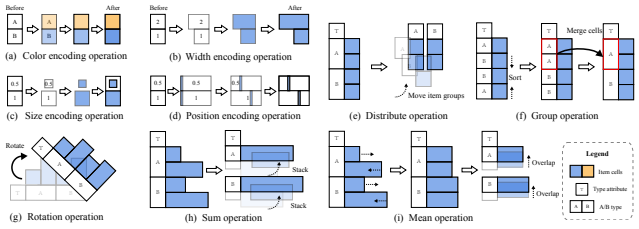

Figure 1: Transition design of operations

We show two cases generated by our method. In Fig. 2, a data table is transformed into a stack bar chart. In Fig. 4, the same data table is transformed into a heatmap with color encoding the sum values.

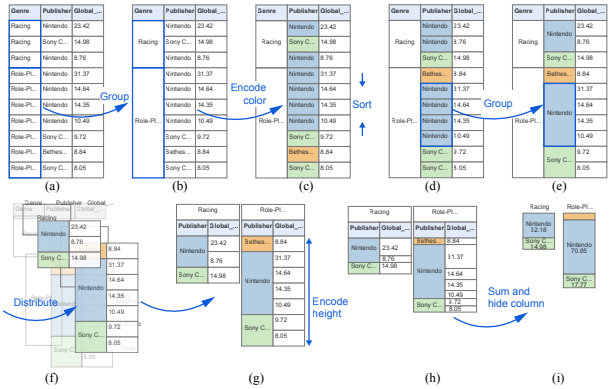

Figure 2: The transition of bar chart. (a) Table (b) Items grouped based on *Genre* (c) Color of *Publisher* encoded (d) Items reordered by *Publisher* (e) Items grouped by *Publisher* (f) Groups rearranged based on *Genre* along the axis X (g-h) The height of cells resized according to *Global Sales* (i) Bars with the same color merged to reach the final visualization.

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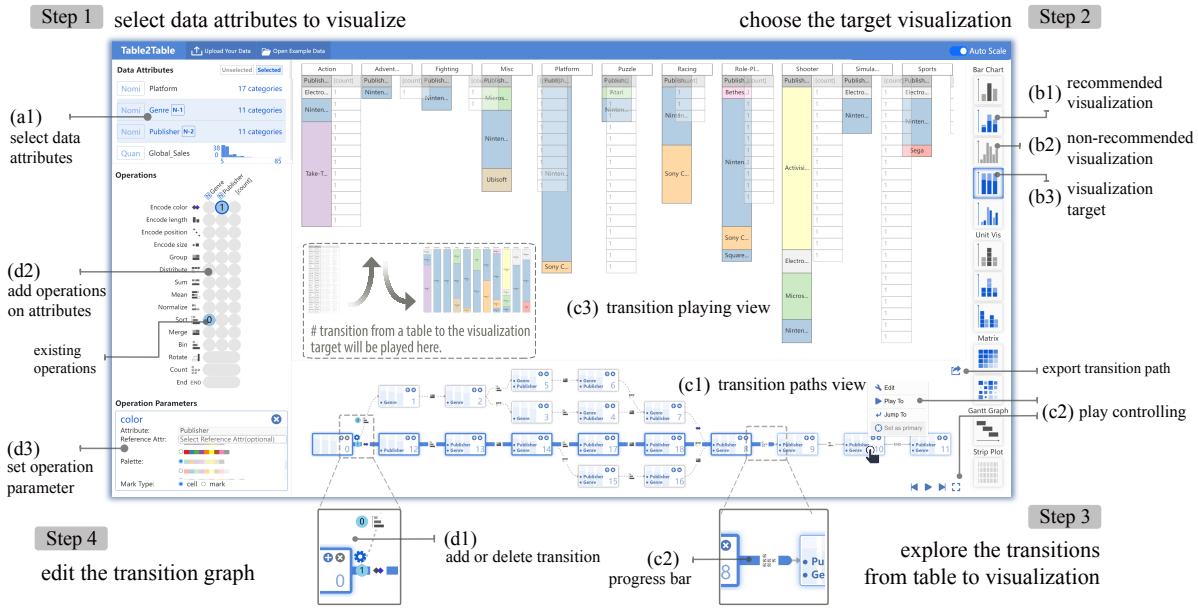

Figure 3: Interface of the Table2Table system.

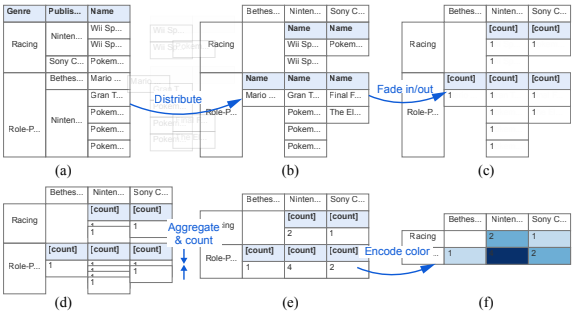

Figure 4: The transition of heatmap. (a) items grouped by *Genre* and *Publisher*, (b) items distributed, (c) cells set to be 1, (d) cells are moved to aggregate, (e) count values calculated, (f) color channel encoded.

3 System

We propose a system supporting users in exploring the recommended transition paths from the data table to visualization. In the workflow of our system, after uploading the table data, a panel on the left top will show data attribute information, like attributes categories or data distribution of a quantitative attribute, to provide insights for users to choose attributes they are interested Fig. 3 (a1). Then recommended visualizations will be highlighted on the right Fig. 3 (b1, b2). Once the target visualization is selected Fig. 3 (b3), several mostly recommended transition paths will show in the bottom view, organized as a directed acyclic graph Fig. 3 (c1).

In the graph, the nodes represent the intermediate visualization states, and the links represent the operations. For users' sake, the path which we found most comprehensible in the design process and the elicitation study will be set as the major path initially. Users can play forward, play backward, pause, or jump on the transition path Fig. 3 (c2). The stage shows transition animation on the above path view Fig. 3 (c3). Besides the recommended transition paths, users can flexibly create new transition paths with different atomic operations Fig. 3 (d1).

4 Evaluation

We conducted a user study with two steps to evaluate the effectiveness of our method. We invited 14 participants to the study. In the first step, we provide participants with the transition illustrated in Fig. 2. Participants are then asked to describe the transition process. All participants describe the grouping stage (step 1), and 92% of participants noticed the coloring and reordering stage (step 2). Around 62% of participants mentioned the length encoding stage (step 3), and 54% of participants describe the final grouping stage (step 4). Overall, participants can understand the transition process. In the second step, we evaluate whether our method can help participants understand Simpson's paradox. We follow the stimuli and tasks in the work of Pu et al. [1]. We notice that the accurate rate of explaining Simpson's paradox is about 70%, which is quite similar to the result in the work of Pu et al. [1].

5 Conclusion and Future Work

We have presented Table2Table, a framework that describes the structure of visualizations conforming to tabular layouts and a set of unified rules that define transitions from original data to visualizations. An algorithm is applied to generate animated transformations, and a prototype system demonstrates the transition steps. Potential application scenarios of our work involve educating students about visualizations and helping data workers understand the data transformation process.

Acknowledgments

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