Study of Multiple View Layout Strategies in Visualisation

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Abstract

Multiple views is a popular strategy in information visualisation, but for many years researchers have asked questions such as "how many views and what layout strategies do people use?" Answering these questions would help developers create suitable multiple-view systems, but to date there has been little research into these questions. In this short paper, we present initial results of a larger ongoing study looking at how multiple-views are used. For this study, we built a database of images containing screenshots of visualisation tools from articles presented at IEEE VIS from 2012 to 2017. We select suitable images across TVCG journal, conference, posters and workshop papers. We closely evaluate the layout of 340 images of multiple-view systems and consider the layout topology of each image. Our results show that in the past six years, developers use on average (just over) four views.

Keywords: Visualisation, Multiple Views, Layout strategies.

1 Introduction

Multiple views has been used in information visualisation for many years. There are different design strategies from view juxtaposition, superposition of many views, or cleverly merging the view information [2], such as by overloading or nesting [3]. In this paper we focus on view juxtaposition, where developers display information in many side-by-side views. One of the reasons developers use such duplication is to help users understand the displayed information. Perhaps a user understands better one style of visualisation in comparison to another, or perhaps one type of visualisation form makes it easier to perform a task, and another form makes it easier to perform a different task. So by using many different view types the user can gain a better understanding of the underlying data. Another reason to use multiple views is to compare data shown in similar views presented side-by-side. Such tools are described as small multiple views or parallel view systems. Additionally, the manipulation of data within these juxtaposed views is often linked together. In fact, Coordinated Multiple View systems [6] provide the backbone of most modern visualisation systems.

This research is part of an ongoing project investigating uses and layout strategies of multiple views. Our goal is to help and guide developers create well-designed multiview systems; to provide a framework and reference source that designers and developers of new systems will be able to use. This short paper fits within this long term strategy. The purpose of this paper is to report on a study investigating the quantity of views used in multiple view systems, based on tools presented at visualisation conferences. Counting view layouts helps us get one step closer to our goal.

2 Background and Related Work

There are many different ways to layout juxtaposed views, and it is difficult for a designer to know which layout strategy is useful. Indeed, it is unclear which are the most popular layout configurations. We have been exploring layout strategies, and particularly for this paper we have been investigating the relationship between the *number of views* and the configuration of the *layout* of juxtaposed views. As researchers ourselves, we have developed and designed several Coordinated and Multiple View systems, and have had many discussions with other researchers about the use and layout strategies of multiple-views. But to date there is little quantitative research looking at view layout. Certainly there are several papers that provide guidelines for designers of multiple view systems. These include Baldonado et al. [8] who suggest that multiple views should be used parsimoniously, while on the other hand, Roberts [5] encourages designers to use many views. In other work, Roberts [6] provides a comprehensive review of coordinated multiple views techniques. In fact, the series of conferences on "Coordinated and Multiple View" that ran 2003 to 2007, published by IEEE provide a set of useful reference papers on various CMV techniques. Gleicher et al. [1, 2] provides a deep discussion into juxtaposition, superposition and explicit designs for multiple view systems, and Qu and Hullman [4] present strategies to keep multiple views consistent.

3 Study Methodology

To evaluate the multiple view layouts we went through three steps: (1) we decided which images we would use, and copied them from the papers into a separate database. (2) We considered each visualisation, made a sketch of the topology, and classified them according to their layout by physically organising the pieces of paper on a table. (3) We counted the different layouts and gathered quantitative data of the types and layouts.

3.1 Preparation and image selection

For our study, we chose to evaluate the tools presented at the recent six years of the IEEE VIS conference. There are over 2912 PDF files on the six years of USB memory sticks from the IEEE VIS conferences. Estimating that each file probably has more than one image, and that not every image presents a screen capture of a visualisation tool, we needed a strategy to select (and reduce) the quantity of images to evaluate. After deliberation and experimentation, our strategy was fourfold: (1) We removed all supplementary materials. (2) We removed papers that did not have visualisations, or only had one view, or only had illustrations and schematic diagrams. (3) We removed files that only had images that were clearly put-together or had been edited (by an image processing tool), we looked for telltale signs, such as miss-aligned sub-images or several image resolutions in different parts of the figure. We also removed papers that had displayed their images from several sub-figures. (4) We removed papers that only had extremely small sized figures at low image resolution, which would have been unclear to classify. This process resulted in a bank of 340 images. We labelled each image with a unique abbreviation (that we also use in LaTex to cite the paper). This meant that we could easily reference the image, and locate the associated publication.

3.2 Considering the topology, and sketching layouts

For this short paper we are only concerned with the topological layout of the designs. In other words we evaluated the structure of the layout, ignoring their relative sizes. For example, we consider a side-by-side two-view display with one small view and the other

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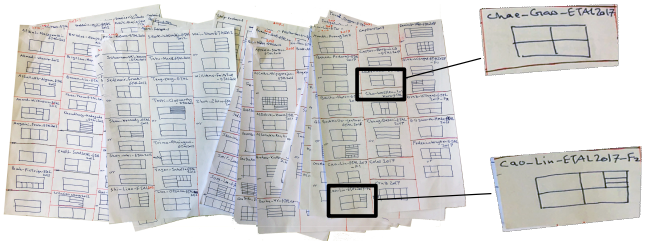

Figure 1: For every image we sketched a representative picture of the layout topology, resulting in 17 sheets of paper of sketches.

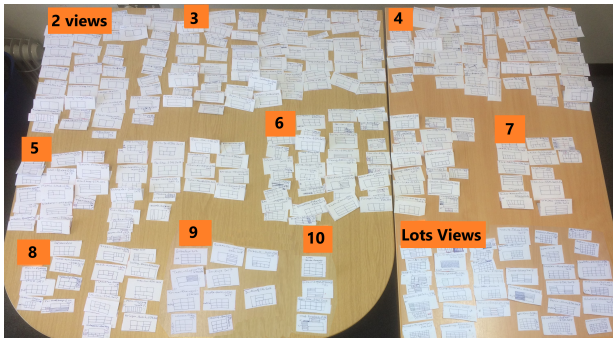

Figure 2: The 17 sheets were cut into individual tiles and positioned on a table. This shows a visual quantitative summary of view layouts.

one large, to be structurally the same as another visualisation that has equal 50/50 split of the size of the each view.

We displayed each image in turn on a large screen, and carefully make judgement on the topology of each of the 340 images. We make several judgements and notes on the images. We had two investigators evaluate the images. From early discussions about the topology we realised that some images were easy to judge, while others were not clear. Therefore we started with a training phase. The two investigators classified individually 20 (randomly chosen) images. Out of this set, five were unclear. But after discussing these cases, we easily agreed the topology.

Subsequently we proceeded as follows: Every image was displayed on the screen and judged. If a quick judgement could be made then one simple (indicative) sketch was made on a piece of paper. However, if the topology was unclear, then every possible topology was sketched. Every sketch was also labelled with the paper reference. From 340 images, we generated over 17 sheets of paper (with on average over 20 sketches per page). We discussed 124 cases and agreed their topological structure, and randomly checked another 10 to make sure we agreed with a selection of the other cases. A photograph of the sheets is shown in Figure 1. The agreed sketched images were then cut up into individual tiles, keeping only the agreed topologies.

We used a tangible method, where we placed the tiles on a table, discussed their layout strategy, and physically moved the pieces of paper to place similar layouts together. This method enabled us to discuss different cases and categorise them appropriately. Figure 2 shows a photograph of the final layout, which shows the relative quantity of each layout.

4 RESULTS AND DISCUSSION

The table-top presentation of the strategies (Figure 2) gives a quick visual overview, showing that three and four view-layouts are most frequent. Figure 3 shows the trend, that as the view count increases there is less agreement in design strategies. We realise that the purpose of the visualisation would change depending on the quantity of views used: with fewer views a user interacts with specific views; with many views the user is less likely to manipulate one view, but

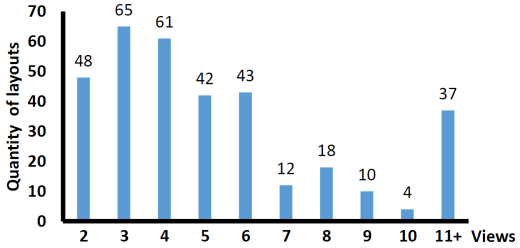

Figure 3: Bar chart showing the quantity for each view layout. On average designers use 4.5 views, when ignoring the small-multiple displays of 11 and more views.

gains an overview of the information from all views. We can calculate an average of the large-view multiple-view tools by removing the 37 tools (from 340) that have more than 10 views, and calculate that the average view layout is 4.5 views.

We have started to investigate the structures and layouts and tasks associated with these views, which will be presented in follow-on work. We estimate that on average 25% of all layout strategies are unique, and there is less similarly with higher view counts. This demonstrates that developers are creating individual layout designs, but the majority of the design layouts are similar; which gives us hope to provide quantitative view guidelines. We also notice that while our simple view count method may express that views are similar, in practice they may include different forms. They are less similar when they are investigated in detail. We also notice that certain layout configurations afford particular visualisations and tasks. For example, those that contain a long thin view are typically used for a timeline, or a line graph.

We acknowledge limitations to our study. We focused on the past six years of tools presented at IEEE VIS. While we have looked at a broad range of structures we only present the topology results in this paper. We only present results on view juxtaposition, and not on superposition, overlay or nesting. We also acknowledge that the visualisation domain is evolving. Many visualisation tools are presented on the Web, developers are non-academic and therefore would not present their work at the IEEE VIS conference, and there is a rise of immersive and interactive visualisation experiences. In fact, we believe that there are many opportunities to look beyond WIMP based (fixed screen) solutions [7], and we believe that this change will have an impact on the area of multiple views.

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