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 framework and reference source that designers and developers of new systems will be able to use. This short paper fits within this framework and reference source that designers and developers of new systems will be able to use. This short paper fits within this framework and reference source that designers and developers of new systems will be able to use. This short paper fits within this framework and reference source that designers and developers of new systems will be able to use.

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

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

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 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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REFERENCES