Future Directions for Visualisation

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Abstract

The design of a visualisation invariably depends upon the task(s) and the target user group it is designed to support. Exploratory and explanatory visualisations generally require different considerations. We consider the future of visualisations from this perspective.

1 Introduction

In order to envision a future of visualisation without desktop computing, it is beneficial to start by considering future contexts of use and potential tasks.

Particular applications of visualisation are often classified according to their purpose: *exploratory* or *explanatory* [4, pages 7–8]. Exploratory visualisation is usually associated with the exploration and analysis of an unfamiliar dataset in search of insights. Exploratory visualisations are typically used by trained experts in visual analysis, often with powerful computing hardware and large (sometimes multiple) screens.

In contrast to exploratory visualisation, explanatory visualisation is typically used to convey one or more insights into a dataset *after* the insights have been discovered. A typical example might be an interactive graphic prepared for an online newspaper, perhaps with an interactive storyline synchronised to a series of predetermined views of the dataset to illustrate particular aspects of the narrative. Explanatory visualisations are sometimes used to convey a particular perspective on a dataset, according to the underlying intentions of the author. If it is easy to lie with statistics, it is even easier with an explanatory visualisation!

Computing hardware is becoming increasingly powerful and ever smaller with decreasing power requirements. At the same time, the desktop metaphor and its WIMP (windows, icons, menus, pointer) style of interaction, predominant for over 3 decades, now has some serious competition. Much smaller displays (than desktop monitors) and much larger displays are both increasingly more commonplace. Augmented reality and immersive technologies offer further possibilities for output to a user. Touch interfaces (characteristic of smartphones and tablets), gestures (Wii and Kinect), and voice (Siri and Android) all provide alternative means of user input. Even more recently, 3d printers, laser cutters, and other technologies, have opened up further possibilities to physically visualise datasets.

2 Future Exploratory Visualisation

Exploratory visualisation today is typically performed by trained, highly skilled, expert analysts. We do not expect this to change. The displays used today are typically large and visually dense. We do not expect this to change either.

On the visual analyst's desktop, very high resolution displays, or banks of several connected displays next to one another [2] are now possible; the decreasing cost of corresponding graphics cards and monitors will see this trend continue. We would expect, however, the keyboard and mouse to continue to be the main mode of interaction with these systems.

Figure 1: Dust clouds overlaid atop a city model to visualise air pollution statistics.

Some researchers have experimented with room-sized display walls [9]. In addition to the more obvious problems of synchronising output to multiple tiled displays, there is the additional problem of how to enable user interaction with such displays. Since the traditional mouse and keyboard proved insufficient, researchers have experimented with both gesture and voice input [16].

From their beginnings with the CAVE [1], virtual environments such as the DAVE [7] have been adapted for exploratory visualisation applications. In a prototype at Graz University of Technology, a virtual world representing the city of Graz has been built, in which dust clouds are used to represent location-based air-pollution statistics (see Figure 1). The density of the clouds rendered in different city parts represents the mean concentration at the specific location. The multi-user capability of such recent virtual environments allows the distinction between exploratory and explanatory visualisation to be blurred: an expert can collaboratively guide one or more visitors through the scenario.

Beyond hardware considerations, recent research into adaptive visualisations has led to systems which recognise and are able to adapt to their environment, their context of use, and even their specific users. For example, Mutlu et al. [10] and Leida et al. [8] use the semantic characteristics of the dataset to automatically suggest a suitable visualisation to the analyst from a palette of available visualisations (see Figure 2). Nazemi et al. [11] enhance exploratory visualisations by tracking the behaviour of users and adapting the visualisations accordingly.

3 Future Explanatory Visualisation

Whilst we expect exploratory visualisations to move towards even larger displays, explanatory visualisations are spreading to both larger and smaller displays simultaneously. In the context of public displays, we may see the introduction of wall-sized explanatory visualisations. For example, a wall-sized visualisation of the realtime locations of public transport vehicles such as Linz Fährt [15] (see Figure 3) could easily be realised for a bus station foyer. How could the public interact with such a visualisation: maybe smartphones could be enhanced with a modified laser pointer (carrying

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Figure 2: In the CODE project, the software picks a suitable visualisation after analysing the semantic characteristics of the dataset. Here, a parallel coordinates visualisation has been chosen for a multidimensional dataset.

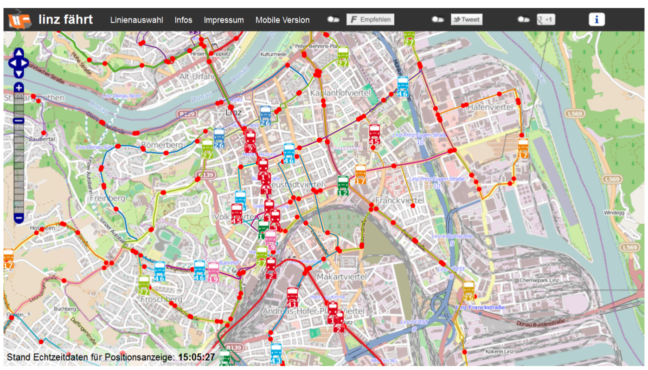

Figure 3: Linz Fährt is a web-site displaying real-time locations of public transport vehicles in the city of Linz.

some kind of id?), so that a viewer can point at a particular bus and call up its details?

Explanatory visualisations and simulations are already being used inside virtual environments to help teach physics students about phenomena like Faraday's Law [14] (see Figure 4) and to visually illustrate the behaviour of sorting algorithms [13] (see Figure 5). Other applications of visualisations of 3d phenomena can easily be envisaged.

The confluence of data journalism and responsive web design has led the charge to spread information graphics and explanatory visualisations to the general public. Newspapers such as the Boston Globe, New York Times, and the Guardian are actively developing explanatory visualisations [6] which work well both within the confines of a smartphone screen, as well as on more traditional desktop displays. Figure 6 shows an example from the Austrian state broadcaster ORF [12] with a bar chart of the Austrian general election results in 2013. When less space is available, the visualisation adapts by removing the absolute numbers or votes.

Finally, a new trend towards both static [3] and dynamic [5] physical visualisation (or data sculptures) is showing promising early results, particularly for explanatory visualisations.

4 Concluding Remarks

To conclude, we see the future of visualisation as increasingly diverse. Displays will become both larger and smaller. Novel meth-

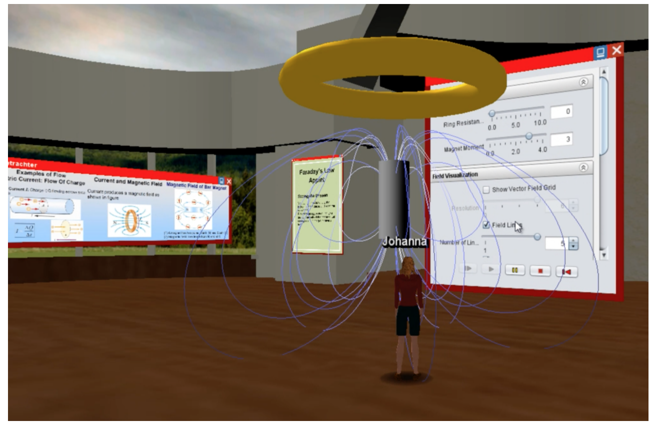

Figure 4: Teaching Faraday's Law to physics students inside a virtual environment using an interactive simulation and visualisation.

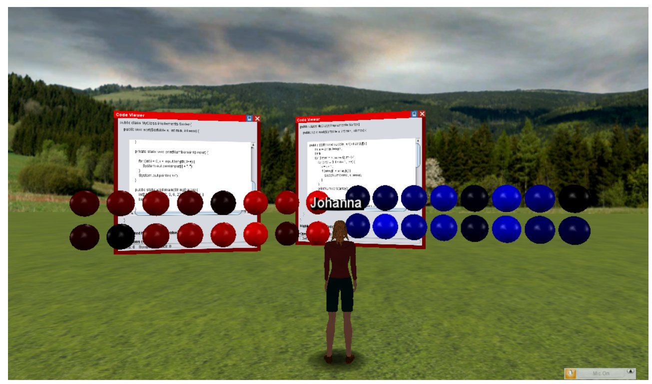

Figure 5: Teaching sorting algorithms to students inside a virtual environment using an interactive simulation and visualisation.

ods of interaction will be introduced to visualisations. Visualisations will adapt to their users and their environment. Physical visualisations will provide an intriguing alternative. Throughout these advances, consideration of the purpose of a visualisation will continue to drive the best design for a specific task and user group.

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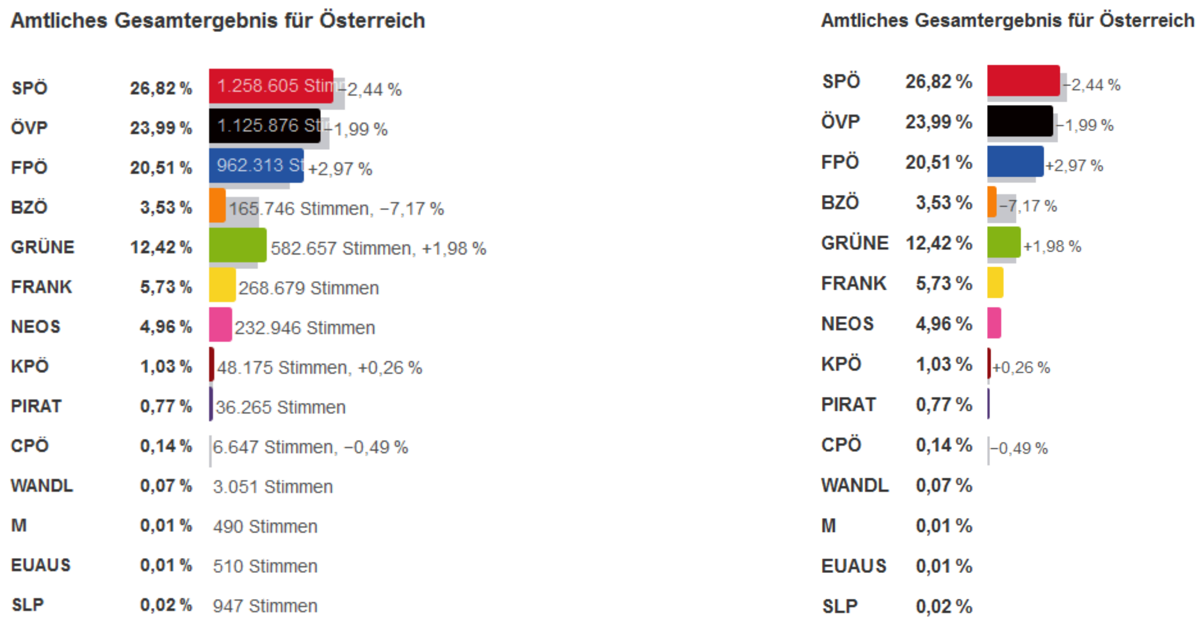

(a) The bar chart at a width of 560 pixels. **(b)** The bar chart at a width of 360 pixels.

Figure 6: A bar chart which responds to having less space available by removing the absolute number of votes. [12].

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