Time in Perspective: a visual approach to models of time

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Abstract
Geographical representations of topographical space come in many shapes and are a regular topic of discussion. The depiction of the invisible and maybe even illusory concept of time on the other hand, remains largely unchanged and undisputed. A uniform and arithmetic model of time fits well with the rigid structure of digital data, which might be why it has been widely adopted within HCI. In our proposal, we will present historic and contemporary approaches that offer alternative perspectives on the visual representation of time.

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Time, Chronography, Visualisation, HCI, Cognition

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General Terms
Design, Human Factors, Theory

Introduction
Our proposal is concerned with models of time and especially with what time should look like. What shape is it, what are its contours and its texture, from where is it best viewed? What are the effects on the user of

different solutions to these questions? Our research looks both back and forward, investigating pre-digital formats while also devising new interactive digital visualisations. We investigate the past in order to undermine assumptions about how time 'really is'. We also look at research in cognition, and have previously undertaken experiments to test the memorability of events when visualised using virtual environments (eg. Korallo, Boyd Davis, Foreman and Moar 2013). Our work has implications for several fields of human computer interaction, where visualisations of time provide support and context for activities including the chunked model of digital diaries and calendars, the arithmetic model of quantitative visualisation, the linear model of timelines for authoring media and music, the event-based model of histories and so forth. Time-wise views are increasingly used to present search results (Alonso, Gertz and Baeza-Yates 2009) allowing users to see otherwise undetectable patterns (Manovich 2011). They are of interest in social media (Harper, Whitworth and Page 2012), and in relation to lifelogs and identity (Harper et al. 2008), where the relationship of personal time to social and abstract time are increasingly important.

Conceptual models and visual metaphors

How time is represented really matters. It is remarkable that there is a rich debate over the competing (de)merits of topographic visualisations in geography, with fierce argument over the values of the Mercator, Gall-Peters, Van der Grinten, Robinson, Winkel tripel and other projections, together with important innovations such as Worldmapper (Dorling and Ballas 2011) that exploit digital interactivity to offer permutations tuned to the contingent needs of the user. However, such controversy is rarely raised by visualisations of time. Hopgood (1993) was struck, while developing standards for specifying timebased multimedia, by the tendency to make assumptions about time and space. His conclusion was that 'Europeans have a notion of time and space that is generally assumed by them to be universal. This gratuitous assumption is naive, arrogant and wrong.' In our own work we are not interested in the truth status of any particular model of time. Our approach is pragmatic, considering how activities are best supported by the varying models and pictures of time. Our current focus is on mapping cultural data to time, under a UK EPSRC project.

Figure 1. BBC timeline, A History of the World, Version 1.1 (2010). The z-axis, orthogonal to the picture plane, is used for time. The designers have chosen to put the present time in the far distance, in front of the user. Behind the user is the most distant past. BBC Radio 4, A History of the World http://www.bbc.co.uk/ahistoryoftheworld (used with permission).

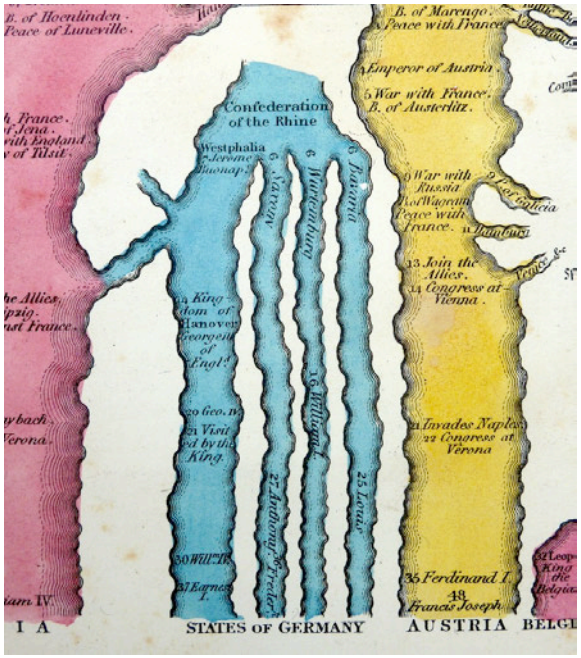

Figure 2. A detail from Strass, F. (1849). Stream of Time, or Chart of Universal History. [London]: C. Smith, Mapseller. Collection: Stephen Boyd Davis. Photo: Stephen Boyd Davis.

Looking at the history of chronographics, it becomes clear that the now widespread model of time as an arithmetical 'space' is only one way of conceptualising time, largely associated with the rationalism of the eighteenth century and derived from Descartes and Newton's shift to quantification. As the workshop call indicates, such linear, uniform models of time have been questioned through the twentieth century. Walter Benjamin (1940) contrasted *jetztzeit* (here-and-now) with the 'homogenous and empty time' of positivism. Zerubavel (2003) has catalogued sociocultural distortions of historic time in which, for example, we compress the perceived time-gap between events seen to be related, and extend that between apparently unrelated events. Some physical scientists doubt that time exists at all, regarding it as an illusion or convenient fiction (eg. Barbour 1999).

Culture, language, mood, age and many other factors affect our perception of time. Whether we can think about time without using metaphors from other domains is questionable (Avery Hunt 2008). Gentner (2003) emphasizes the sheer utility of mapping time to space: location captures elements and their relations; dimension shows duration; it is an eminently usable analogue of an abstract concept. However, if time is mapped to two or three dimensional space, on which axis should time lie? (Tversky 2003; Boyd Davis 2012). And in which direction should later times lie in relation to earlier: what is the direction of travel? Traugott (1975) was one of the earliest researchers to ask why verbal metaphor prefers some directions to others. Analysis of the cognitive science and ethnographic literature shows that, remarkably, the dominant direction for time metaphors in gesture differs from that in language - what are the implications for embodied physical interaction where gesture is as important as language, or accompanies it multimodally? Núñez and Sweetser (2006) conclude that all documented languages, with the apparent exception of Aymara in the Andes, map future events onto spatial locations in front of speakers (see **Figure 1** for a visual example), with past events behind them, though evidence has recently emerged of another rare model that orients time-ordered objects not relative to the observer but relative to the world Boroditsky and Gaby 2010). Margulies and Crawford (2008) found that an

event that is dreaded will tend to be seen as moving towards the observer, while for a more welcome event observers will tend to see themselves as the moving agent. Metaphors of relative motion were common in earlier chronographics and led to visualisations based on rivers and streams (**Figure 2**) mechanisms such as wheels and arrows (Gould 1987), as well as more static organic images such as trees and branches (Boyd Davis, Bevan, and Kudikov 2010) (**Figure 3**) and terrains, influenced by the visual inspiration of geography.

Time as a digital data structure

In recent years an important new contribution has been made by the digital humanities community who, building on the many objections to quantitative, objective, linear time have argued for tools that facilitate 'elaborate, subjectively inflected' representations of time (Drucker and Nowviskie 2004) offering 'aesthetic provocation' (Nowviskie 2004: 40) perhaps partly through 'studied inexactitude' (p93). From an HCI perspective we would normally expect to champion the user's perception of their own needs, configuring systems to fit their world view. But in making time-representations 'comfortable' for users, fitting the digital experience to their presumptions and subjectivities – as some digital humanities scholars ask us to do – do we risk losing some of the advantages that arise when users are confronted with less congenial but potentially more informative models? Forcing events of which we may have a subjective view into a mechanical structure can have benefits for our thinking, whether this means discovering that the first pharaohs of Egypt were further in time from the last pharaohs than we ourselves are, or that that forthcoming deadline is much sooner than you thought.

One of the earliest theorists of chronographics, the dissenting clergyman and proto-scientist Joseph Priestley, noted how a uniform view of time reveals patterns and voids precisely because of its mechanical linearity (Priestley 1764). This reflected a view quite widely held by radicals of his period that mechanical approaches to knowledge had much to offer in contrast to traditional models (Boyd Davis 2010).

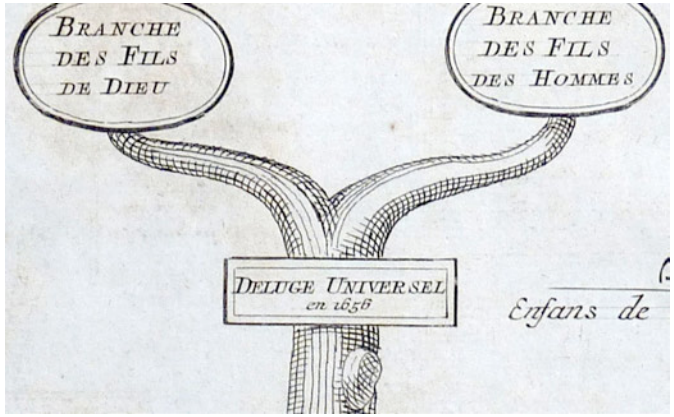

Figure 3. Châtelain, 1721: Chain of Sacred History (detail) from the Atlas Historique. Time as a branching plant. Collection: Stephen Boyd Davis. Photo: Stephen Boyd Davis.

Whatever the answers to these issues, the digital humanities pose important questions for HCI, whose answers may be of wider benefit. Questions again from Nowviskie (2004: 246) include asking how we can usefully represent the unfolding of multiple narratives embodying contradictory accounts, and 'ways of conceiving of future and past in modes that inherently involve transformation of past records and future events' as in anticipation or regret. There is no reason why some of these demands should be limited to the humanities.

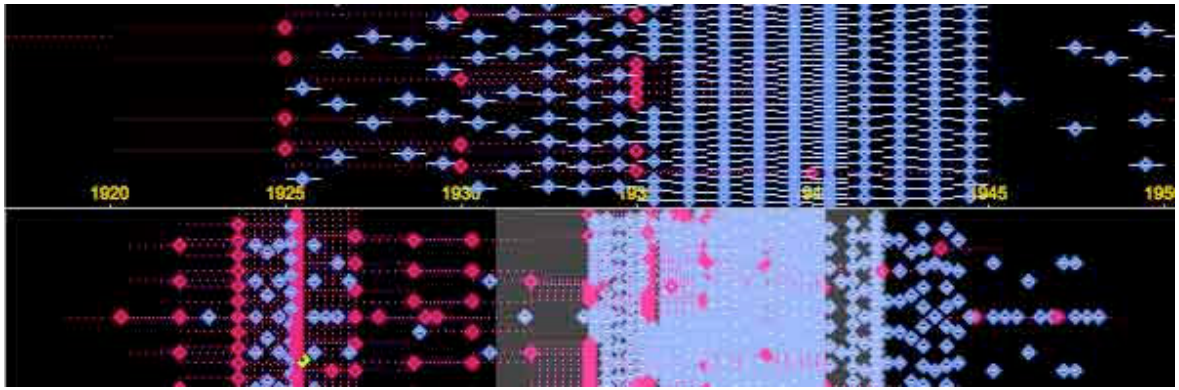

Figure 4. Bevan and Kudikov, 2010. HiT (Historical Interactive Timeline) interface for the Museum of Domestic Design and Architecture, Middlesex University, UK (detail). At top, part of the main view spanning the 1910s to 1950; below, the comprehensive view of the entire dataset.

A useful contribution is the concept of 'mutable and inflected timescales' (Nowviskie 2004: 246). We have argued previously the value of clearly separating the underlying model of time from contingent, temporary views based on the user's current needs (Boyd Davis, Bevan, and Kudikov 2010). One can offer users a range of controls to bend, stretch and otherwise manipulate the current view of the model (or part of it), based on the user's immediate needs, switching instantly between views. A very simple example is the dual-port view now widely adopted which shows views of the same time-space at different scales simultaneously (**Figure 4**). Digital media facilitate this separation of conceptual shape and rendered shape, because they allow the rendered shape to be contingent on the data, the user's needs and any other factors the designer wishes to take into account. Yet the design of most digital chronographics ignores this potential. There is of course a wealth of HCI issues involved in how such manipulations may be afforded to the user and how the resulting inflections should be represented (there are also many solutions to be adapted from earlier practice such as magic lenses, fisheye views etc). A key question here is to what extent we must explicitly author different views of time, to what extent we simply spread out the data in time and let the patterns speak for themselves, and to what extent sense-making can be assisted by the software itself, identifying clusters, flows, coincidences, patterns and connections?

To look at existing digital representations of time, especially in the case of historic time, one would think that no new challenges are presented, since they seem to advance little beyond the achievements of paper chronographics two centuries old or more, and in many cases actually fall short of them in sophistication and subtlety. Our workshop contribution rejoices in the huge variety of depictions of time already in existence, and asks what we can learn from them. The

presentation will include an analysis of key examples of pre-digital chronographics, examples of good and bad recent practice addressing the questions outlined above and demonstrations of our own recent and current work.

About the authors

Dr Stephen Boyd Davis
leads staff research activities in the School of Design at the Royal College of Art. Originally a textile designer, Stephen has for many years been involved in the creative use of digital technologies, including in locative media where digital material escapes the boundaries of the screen and becomes part of our experience in the world. Stephen's latest research is concerned with the visual representation of historical time, especially in interactive digital media, combining historical investigation and the development of new practice. He is a reviewer for the UK AHRC and other RCUK bodies and for many journals and conferences.

Florian Kräutli
holds a BDes from the Design Academy Eindhoven and a MSc in Cognitive Computing from Goldsmiths, focussing on philosophy of perception and artificial intelligence. He is experienced as a designer, software developer and lecturer and is currently pursuing a PhD at the Royal College of Art. His research is centred around interactive data visualisations for cultural data, with a focus on representation of time. Florian collaborates with System Simulation, a London based software engineering company which has wide ranging experience in collections management for clients such as the V&A and the British Museum, and is supervised at the RCA by Dr. Stephen Boyd Davis.

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