Reframing Cultural Heritage Collections in a Visualization Framework of Space-Time Cubes

Florian Windhager[1*], Eva Mayr[1], Günther Schreder[1], Michael Smuc[1], Paolo Federico[2] and Silvia Miksch[2]
[1] Danube University Krems, Krems, Austria
florian.windhager@donau-uni.ac.at, eva.mayr@donau-uni.ac.at, guenther.schreder@donau-uni.ac.at, michael.smuc@donau-uni.ac.at,
[2] University of Technology Vienna, Vienna, Austria
federico@ifs.tuwien.ac.at, miksch@ifs.tuwien.ac.at

Abstract

During the last decades, digitization broadened access to cultural heritage collections for public audiences. Large online databases have been prepared for open access with simple search interfaces or visual exploration methods. In this position paper we discuss new challenges arising from these initiatives with regard to casual users. To meet their specific needs, we introduce a novel method for synoptic collection visualization which makes use of parallel space-time cubes to provide multiple spatiotemporal overviews, support free exploration, and to specifically engage casual audiences.

1 Introduction

To facilitate sustainable access to our cultural achievements, cultural heritage collections provide windows into the past and store data on their objects in multiple dimensions. Curiously enough, it is the successful development of big cultural heritage databases like europeana.eu, which generates new challenges of (in)accessibility: Existing user interfaces require prior knowledge about what is to be found [3] and thus introduce a potential barrier for non-professional visitors or *casual users,* who just want to explore the collection, as we will discuss in chapter 2. Chapter 3 and 4 discuss how Information Visualization (InfoVis) interfaces can provide the means to address these issues - and how some of their limitations could be overcome by a novel interface design, making use of multiple space-time cube representations. As an outlook we discuss possible implementation scenarios in chapter 5.

* Corresponding author

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2 Cultural Heritage and Casual Audiences

Cultural heritage databases aggregate massive amounts of digitized artefacts and associated metadata and allow for queries according to the users' prior knowledge on various metadata dimensions. Yet, just as in museums, visitors often come without prior knowledge. Without a clear goal, they want to interact with a digital collection in an exploratory way [10], browsing through the cultural information, rather than searching for specific details [12]. Also in InfoVis, the needs of casual users in everyday leisure settings have been reconsidered [7]. Their intrinsic factors are to learn something and gain a deeper understanding, but also to simply get entertained [9]. From the outlined research we can derive *design recommendations* for collection visualizations:

- Visitors to digital cultural heritage collections need an orientation phase before they start browsing or searching [10]. Also in information seeking a sense of overview and orientation is regarded important [3:1218]. *Design recommendation 1* [DR1]: InfoVis interfaces should provide effective overviews and conceptual orientation of a collections extension, its major components and arrangement.
- Museum research shows that only limited cognitive resources are available for learning and exploration [2]. *Design recommendation 2* [DR2]: InfoVis interfaces should offer a maximum of overview, while keeping the cognitive load, required for cognitive information integration and orientation low [3].
- With exploration being the central activity in such settings [10,12], casual users often explore InfoVis interfaces without a clear goal in mind. *Design recommendation 3* [DR3]: New interfaces should support exploratory behavior, e.g. by offering multiple perspectives and a rich set of interaction methods to explore object collections on overview and detail levels.

We consider these specific needs of casual audiences to play a crucial role when it comes to the future acceptance and factual use of public interfaces to digital object collections.

3 Visual Interfaces to Cultural Heritage Collections

While physical object collections are commonly explored in a close-up perspective (Figure 1, left) traditional means for overviews are floor plans, as well as lists, slideshows or grids in case of virtual collections. Several InfoVis methods have been proposed to widen the options for visual exhibition exploration. We distinguish between the visual encoding of *spatial* (i.e. cross-sectional, non-temporal) data aspects, and of *temporal* (i.e. longitudinal) data aspects (see figure 1, right), with "spatial" not only referring to geographic metadata, but also to their distributions in algebraic or vector spaces.

Visual Encoding of Spatial Data Dimensions: As place of origin counts among the most frequently documented data dimensions of cultural artifacts, *geographic maps* often serve as a standard visualization method to show the spatial distribution of artifacts' origins. Given different thematic or stylistic classifications of cultural artifacts, *set diagrams* or *treemaps* offer insights into categorically or hierarchically structured data constellations. As for relational data (e.g. influences, references, inter-artifact relations) *network diagrams* or *graphs* enable users to explore the proximities and distances of artifacts or cultural actors in relational or topological spaces.

Visual Encoding of Temporal Data Dimensions: Especially in cultural heritage contexts, interfaces have to encode temporal information too. One prominent option to do so are *linked timelines*, usually implemented as a coordinated temporal view in addition to a spatial representation. Other prominent options are *animation* and *superimposition* with the former merging multiple temporal snapshots

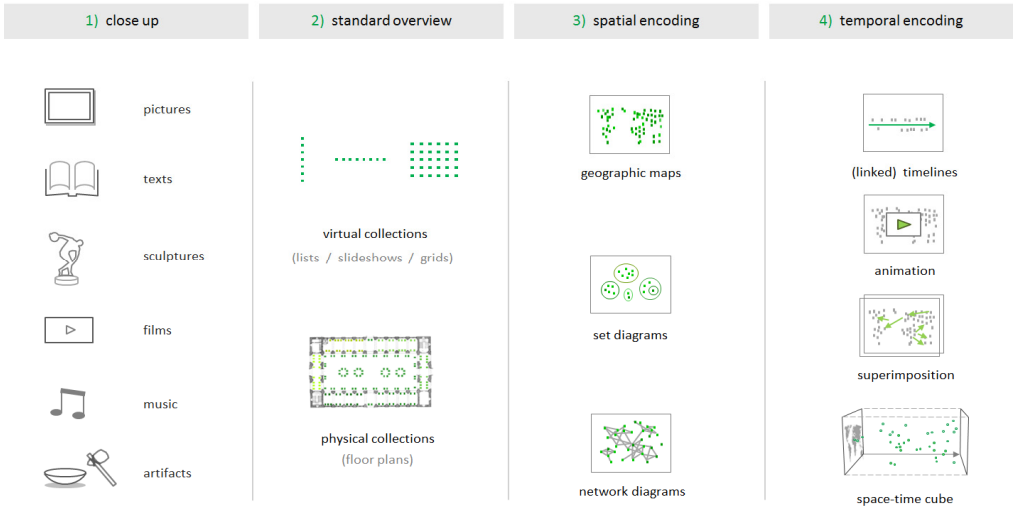

Figure 1: Overview on different methods to visualize cultural heritage collections.

(often distinguished by different colors), and the latter mapping time to time. Another hybrid technique is the *space-time cube* (STC), mapping time to an additional spatial dimension.

As most of these methods have already been implemented in the cultural heritage data domain, we focus on the specific needs of casual users: Which visualizations provide effective overviews while keeping cognitive load low? Which methods provide conceptual orientation as an entry point and support multiple ways of exploration, but also navigating between alternating views? With regard to these questions, we will make the case for a more thorough consideration of space-time cube (STC) representations (cf. figure 2), which have been shown in user studies to have unique strengths in displaying multidimensional data [6], yet have not been implemented and evaluated in the cultural heritage domain until now.

4 A Visualization Framework of Multiple Space-Time Cubes

A visualization framework based on STC representations could support casual users' exploration of digital object collections in various ways, which we will discuss in relation to the design recommendations in chapter 2.

First, the STC supports ***perceptual integration of multiple data dimensions****:* As a generic spatiotemporal visualization method, the STC can display various spatial layouts on its data plane – including maps, sets, and network graphs – and consistently map temporal information to its z-axis. This genuine spatiotemporal layout principle provides "naturally" integrated views of three data dimensions for synchronous perception, which conjoin into characteristically shaped point clouds, clusters, flows, trees, or any other combination thereof (cf. figure 2). Experimental studies show that the STC supports the identification of clusters or overall spatiotemporal patterns fast and efficiently [5], especially in larger data sets [11]. *Deduction:* This integrative character of the STC matches the requirement for effective multidimensional overviews and conceptual orientation [DR1], while keeping cognitive load low [DR2]. Multiple interaction options for STCs further support open exploration [DR 3].

Figure 2: Coordinated multiple space-time cubes, with a geo-temporal (left), a categorial-temporal (center), and a genealogical (right) layout, displaying the same data collection, subselection, and single artifact.

But the STC also allows ***higher dimensional integration****:* More than three data dimensions could be perceptually integrated by either using other visual encodings (like color, size, shape, etc.) within a STC, or by the InfoVis technique of coordinated multiple views, which also can be implemented as *coordinated, multiple space-time cubes* (figure 2). The data planes of such parallel STCs can cover different data dimensions and layouts while sharing the same selection of time. Further interactive integration thus is available through the method of coordinated highlighting of selected data elements or linking and brushing [4]. *Deduction:* The implementation of coordinated multiple STCs extends the method's potential to provide synoptic overviews [DR 1] and allow users to synchronously explore multiple dimensions in parallel [DR 3].

The STC can also ***enhance navigation***: Bach et al. [1] showed how STC representations can provide a navigational device to better understand various temporal encoding methods: The STC integrates multiple well-established 2D perspectives while demonstrating their operating principles by seamless canvas transitions [8]. *Deduction*: As an advanced navigator, STCs can support the exploration of a collection's temporal aspects with multiple methods [DR3], while simultaneously showing how different methods of temporal encoding translate into each other, thus reducing the cognitive load for required operations of perspective and information integration [DR2].

Based on these results we conclude that a visualization framework based on (multiple) STCs meets a substantive amount of design requirements for casual users. With regard to expected additional cognition and navigation support in connection with regular 2D views we consider its further evaluation in the cultural heritage data domain to be a productive research endeavor.

5 Discussion and Outlook

In this article we introduced an InfoVis approach to answer new challenges arising from the paradoxical (in)accessibility of cultural heritage databases for casual audiences. We found strong evidence that a multi-method interfaces based on the STC has the potential to meet essential design requirements delineated for casual audiences: They provide a synoptic overview on multidimensional collection data and enable users to generously explore collections from various spatiotemporal vantage points, while offloading data integration to 3D perception and keeping cognitive load low.

As a conceptual draft, this framework will be able to demonstrate its efficiency only in a series of user studies to come. Since implementations in the cultural heritage contexts have been missing until now, we expect a combination of comparative prototype evaluations to bring along new insights, about how different encoding methods (cf. figure 1) will perform with casual audiences. Possible implementation scenarios range from local implementations for visual collection exploration to extended knowledge communication initiatives in collaboration with various historically oriented disciplines, including Art History, Classical Philology, History of Science, History of Technology, Literary and Media Studies, etc. We further expect contributions to pedagogic and didactic methods development within these fields, i.e. on methods which support the multimodal teaching, presentation and collective exploration of historically oriented topics.

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