Visualizing Biographical Trajectories by Historical Artifacts:
A Case Study based on the Photography Collection of Charles W. Cushman

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Abstract

The digitization of cultural archives and historical records is opening up new avenues for biographical research and teaching. On the one hand, historical ouevres and lifework collections can be newly visualized for different audiences. On the other hand, biographical trajectories can be represented and analyzed in an unforeseen manner. But how do visualizations of life and work go together? With this paper we reflect on ways and means how to shed light on the life of artists or other historical actors by the means of metadata provided by their ouevre. By representing the works of Charles W. Cushman in the PolyCube framework for cultural collection visualization, we shed light on aspects of his biography in a geo-temporal and categorial-temporal information space. We discuss how these visual-analytical frames of reference could be combined for their mutual contextualization, and how they can be hybridized with textual sources to provide a multimodal, narrative framework of biographical knowledge exploration and communication.

1. Introduction

Oftentimes, historical object collections containing artifacts, assets or correspondences of artists, are bequeathed to archives or institutions. These corpora can provide researchers with numerous insights into an artist's life and work on various levels. However, such rich collections also bring along thorough challenges for researchers in terms of knowledge organization and information integration. They frequently contain large amounts of objects and documents, and the associated object information constitutes a complex and multi-dimensional information space. Thrown into this space, it thus is frequently difficult and time-consuming for biography researchers to develop a macro-analytical understanding. Also, as Sandweiss notes, "*the question is whether the digitization of images and their new accessibility over the Internet fundamentally alter[s] the meaning of the original pictures or whether they instead give us greater access to those original meanings. [...] We must develop new interpretive skills to understand this new visual medium*" (Sandweiss, 2007b, p. 201).

In this paper, we explore two corresponding types of "distant viewing"-techniques for cultural collections (Bender, 2015) and investigate how they can complement traditional skills of object-oriented "close viewing"-approaches to biographical interpretation. Information visualization is known to generate "visual representations of abstract data to amplify cognition (Card et al., 1999, p. 637). They enable the interactive exploration of large amounts of data and facilitate the analysis and understanding of various distributions and patterns within. At the present time, biographical databases tend to offer only basic visual representations of individual data dimensions. Exemplarily, many interfaces utilize maps or timelines, which allow to analyze a per-

sons' life events over time or in geographic space (Russo et al., 2015; Leskinen et al., 2018; Filipov et al., 2019), but they rarely allow to analyze multiple dimensions in an integrated manner (Schlögl et al., 2019). Going beyond such one-dimensional views, synoptic visualization techniques can provide richer insights into the multi-dimensional entangled information spaces of biographies (Windhager et al., 2018c) and combine visualizations of life and work.

In the PolyCube project (Windhager et al., 2016; Windhager et al., 2018b) we develop methods to visually explore the multidimensional data of cultural collections (see section 2). We will present a case study based on the photographs of the archive of Charles W. Cushman (section 3) and discuss the implications of such an approach for biographical and prosopographical research (section 4).

2. PolyCube: Visualizing Cultural Collections

The PolyCube project revolves around the question, how multiple data dimensions can be presented in an integrated visual manner to support users in gaining a better understanding of a given collection—a "more integrated mental model"[1]. Due to its relevance, we put specific emphasis on the visual integration of time-oriented data. In the cultural heritage domain *time* has been shown to be a crucial data dimension (Dörk et al., 2017; Windhager et al., 2016), which also requires specific visual-analytical attention.

Conventional visualizations of cultural collections oftentimes build on 'coordinated multiple views' (Windhager et al., 2019), for instance combining a geographic map with a timeline. These spatially separated representations are reconnected via interaction methods, for instance by techniques of coordinated highlighting or linking and brushing
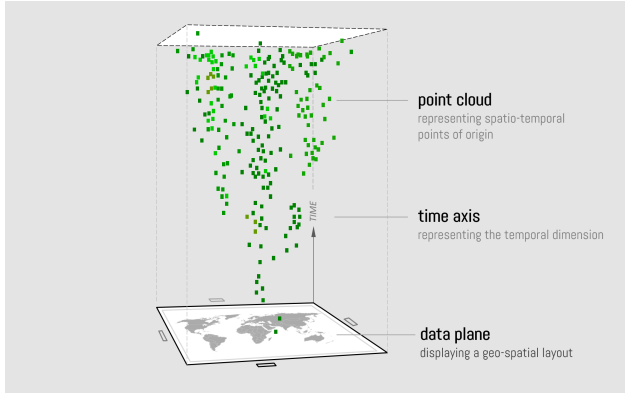
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[1] https://donau-uni.ac.at/en/polycube

Figure 1: Geo-time cube representation depicting the spatio-temporal origins of cultural objects.

Figure 2: Set-time cube representation of a collection's categorial-temporal development.

(Roberts, 2007). However, user studies comparing coordinated views on space and time with more integrated spatio-temporal views show that the latter are superior for the identification of spatio-temporal patterns in the data (Amini et al., 2014; Mayr et al., 2018). Against this backdrop, the PolyCube project develops and evaluates spatially integrated visualizations, which depict multiple data dimensions in one visual representation. In the following we will present two visualization approaches building on the so-called space-time cube (Hägerstrand, 1970). Space-time cubes commonly integrate geographic and temporal data dimensions (section 2.1), yet can be extended to integrate also categorial and temporal data dimensions (section 2.2). Finally, we discuss how the resulting representations can be synthesized to an even higher-dimensional picture (section 2.3).

2.1 Geographic Space-Time Cube

Various visualization methods have been developed to represent spatial and temporal data aspects in an integrated fashion[2]. In the following, we zoom in on geographic space-time cube representations (in short *geo-time cube*), which merge a map and a timeline in an orthogonal fashion, to unfold a three-dimensional, cubic space (Gatalsky et al., 2004). This technique thus allows to map the spatio-temporal origins of cultural objects as a three-dimensional point cloud (Kraak, 2005; Windhager et al., 2018b) and enables a direct (gestalt-perceptual) integration of spatial and temporal information. Commonly, these point clouds represent historical developments in an upward dynamic, which orders the earliest objects at the bottom and arranges the latest artifacts at the top (see figure 1).

From a cognition perspective, geographic space-time cubes offer a specifically balanced design, by which temporal and geographic origin are both mapped to a shared display space, making temporal and spatial information aspects similarly salient via positional encoding[3]. Evaluations confirm that space-time cube visualizations are easy to use,
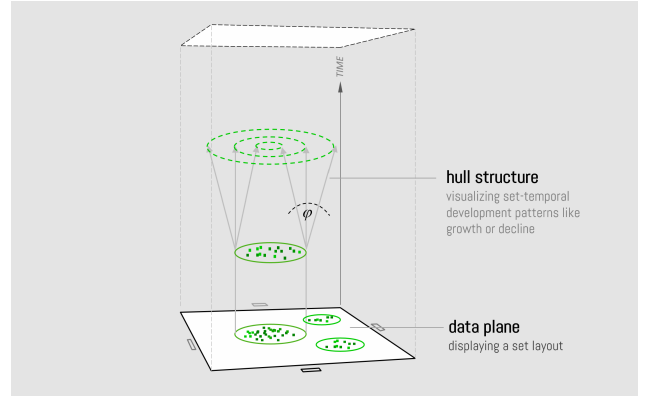
convey a high user experience (Kristensson et al., 2009), and are especially suited for the exploration of multivariate, spatio-temporal patterns (Amini et al., 2014; Kjellin et al., 2010; Mayr et al., 2018).

In our implementation (Mayr et al., 2018), users can interact with the geographic space-time cube by rotating the view, zooming and panning, and selecting individual objects for a close-up preview with details on demand.

2.2 Categorial Space-Time Cube

In cultural collections, categorization is an important technique used to organize and delineate the parallel existence of genres, motifs, movements, or topics. Cultural categories or taxonomies thus group artifacts into set-typed ensembles—which also develop over time. The strengths of space-time cubes in supporting the temporal exploration of larger datasets can also be leveraged for non-geographic data structures (Vrotsou et al., 2010). As such, they offer an effective solution to also visualize the dynamics of sets and their subsets as intuitive visual shapes of time. In a categorial space-time cube (in short:*set-time cube*) the data plane does not visualize a geographical distribution of data points, but an arrangement of multiple sets chronologically ordered from the earliest at the bottom to the latest at the top (see figure 2).

To facilitate the interpretation of the temporal development of individual sets, users can activate a "hull" structure in our implementation of a set-time cube, which connects the geometrical vertices of each set over time. Missing data at one point in time will show up as gap within this hull structure. The shape of this hull allows users to easily trace the temporal development according to the angle (ϕ) of sets and shows basic flow patterns of set dynamics, such as emergence, growth, diminution, and decline (Windhager et al., 2018b). A user study confirmed this ability to support users in tracing developments of different categories over time (Salisu et al., 2019).

Furthermore, users can interact with the visualization by (de-)activating the hull, rotating the view, zooming and panning, highlighting one or two sets, and selecting individual objects for a preview and details (Salisu et al., 2019).

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[2]See the work of Kriglstein et al. (2014) for a review of the advantages and disadvantages of different integrated visual representations.

[3]Position as a visual variable is known to be the easiest to decode by users (Cleveland and McGill, 1984).

2.3 PolyCube: Coordinated Space-Time Cubes

Similar to two-dimensional views, three-dimensional representations can also be combined to form "coordinated space-time cubes". As a coordinated assembly, multiple cubes offer a spatially proximate depiction of the temporal development of cultural collections in geographical *and* categorical space-time. To support users in linking these representations, interaction techniques (such as simultaneous temporal or categorical filtering or highlighting in both cubes) can help to explore parts of a collection in a coordinated fashion. In the following we will outline, how such a visual-analytical environment for object collections can also be used to shed light on the life of historical actors—and thus support the investigations of historians and biographers.

3. Case Study: Charles W. Cushman

As a use case, we focus on the life and work of Charles Weever Cushman (1896-1972), who was a well-travelled amateur photographer and U.S. citizen[4]. Visitors to the Cushman archive are introduced to his life with a short biography, recollecting essential facts on his background and activities[5]. This text summarizes the rather sparse information known about his life, and points out the need for further enrichment by itself—a condition which applies for many historical records of historical actors.

3.1 Biography

Charles W. Cushman was born in 1896 in the American Midwest (Poseyville, IN), studied law and worked for different companies close to Chicago. He was married twice—in 1924 and 1970—and died on June 8, 1972. Stations of his winded life-path led him to work for a railroad office (1917), in the Navy during World War I (1918, honorably discharged from reserves in 1921), for Lasalle Extension University (1922-1928), for a statistics office (1928-1932), and for a brewery company (1932-1937). From 1937 until 1942 he was *"not employed [...] and had no permanent residence. Traveled extensively"*(Indiana University, 2017). During World War II, he worked at the office of the Alien Property Custodian (1942-1944) and at the war department in Chicago from 1944 onwards.

Figure 3 presents a visualization of all these stations of Cushman's space-time path, as extracted from the above-mentioned text [6]. After World War II, though, the biography states that *"with the exception of what may be gleaned from his images, virtually nothing is known about Charles' career and life"* (Indiana University, 2017).

It is not only for this blank period of Cushman's life—but also for an unknown and travel-intense segment between 1937 and 1942—that objects contained in his photography
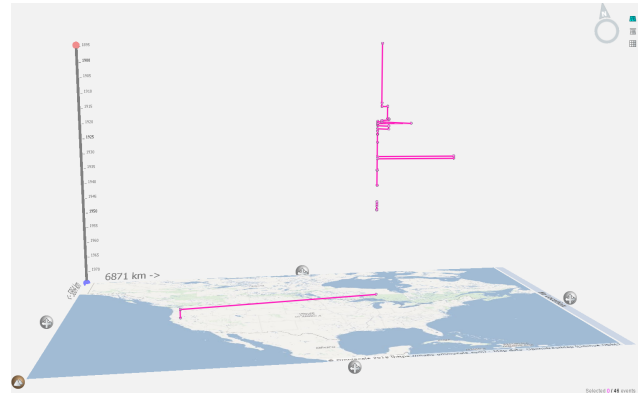

Figure 3: Space-time path of Charles W. Cushman according to one selected biographical text, as visualized with GeoTime (Kapler and Wright, 2004)

collection can fill in rich information and shed light on his biography [7]—and more general on life in the U.S. that happen to see a massive economic, political and cultural upswing in these times. Figure 3 models these two periods of missing information as interruptions of Cushman's biographic pathway. While we also see a need to honestly represent uncertain or missing data in many areas in such an explicit fashion (Windhager et al., 2018a), every biographer firstly has to explore options how to complement and enrich sparse data with additional information. Thus our guiding question is: *How can we complement existing biographical data with implicit information or metadata, inherent to existing archives of their lifework?*

Other reflections on Cushman's life and work (Sandweiss, 2007a, 2012) confirm not only periods of missing information, but also add knowledge about a very critical event in Cushman's life: On March 19, 1943, his suicidal wife Jean shot two bullets into his head—and one in her own—and both survived. From this external data point we derive the additional question: *How did this event influence his travel activities and photographs?*

3.2 The Cushman Collection

The Indiana University—to which Cushman bequeathed his lifework—features a digitized collection of 14.500 of Cushman's Kodachrome photographs from 1938 to 1969 (Indiana University, 2017). In this case study, we have a closer look at a sample of about 2000 photographs taken between the years of 1938 and 1955, with the aim (1) to amend our knowledge of his biography in these years and (2) to understand how the shooting in 1943 affected his behavior.

Cushman consistently documented his activities by the means of a travelogue, listing locations and dates for all his photographs together with a short content description. This information has been transcribed for all pictures, and

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[4]We chose this individual because the collection of his oeuvre is fully digitized, and well documented with metadata.

[5]https://webapp1.dlib.indiana.edu/cushman/overview/cushmanBio.jsp

[6]Due to the design of the utilized GeoTime package (Kapler and Wright, 2004), this space-time path is read from top to bottom – as opposed to the other representations in this paper, which follow the conventional bottom-up reading direction.

[7]As Martha Sandweiss (2007b) formulates it: "Historians more often confront the difficulties of interpreting images *without* extensive biographical information on the photographer than those of interpreting pictures in light of the photographers own readings of them." (p. 194)

the resulting catalogue has been further enriched with geo-coordinates by Miriam Posner (2014) and with information on pictures' subject content according to the Library of Congress (2010) Thesaurus for Graphic Materials. As such, each picture has been assigned to one primary and multiple secondary genres (e.g., "architectural", "identity", or "landscape" photographs).

3.3 Collection Visualization

To gain a better understanding of Cushman's photography collection, we use the PolyCube system to visualize the geographical and categorial patterns of the photographs with their temporal developments between 1938 and 1955. We will first discuss the geo-temporal dispersion of the photographs as indicator of Cushman's travel activities, and emphasize new information which they provide to fill a good part of both blank periods in figure 3. Then we will take a closer look at the categorial-temporal developments within the collection, before we finally demonstrate how even higher-dimensional questions can be explored by means of coordinated multiple cubes.

Travel Activities

Figure 4 introduces a geographic space-time cube representation of Cushman's photographs between 1938 and 1955. In this representation, early photographs are shown at the bottom (violet) and the latest ones at the top (yellow). The widely scattered positions of the pictures near the bottom document Cushman's extensive travels through the United States between 1938 and 1942. For this period of time, the online biography just recites Cushman's own statement on his application form for Federal Employment: *"Not employed during this period and had no permanent residence. Traveled extensively. Looked after personal interests, principal of which was interest in contract of sale of Drewry's business"* (Indiana University, 2017). By contrast, the meticulous metadata of his photographs fills in a rich and detailed pattern of coast-spanning movements, which reminds the observer of trips recorded by modern satellite navigation. By rotating the cube, digital biographers can explore these travel patterns from different perspectives and can see Cushman visiting the West Coast (1938, 1940), the Midwest (1938, 1939, 1940), Florida (1939), and the East Coast (1939, 1940, 1941). Sandweiss (2012) argues that these trips "represented Charless attempt either to take Jeans mind off her troubles or, quite differently, to give himself a break from the tensions of daily life together" (p. 126).

From 1943 onward, Cushman remains quite stationary within the Chicago region – even after his federal employment in the War Department of the Chicago ordnance district ended. An obvious explanation could be the shooting and his wife's following hospitalization at a sanitarium in Oconomowoc, WI (Sandweiss, 2007a), which is documented with pictures in the collection until June 1950. At the end of 1951, the couple left Chicago and again show similar travel activity to the beginning of the visualized period – if not even more: They undertook several road trips, along the Southwest to the West Coast and through the Midwest. In 1952, the couple moved to San Francisco
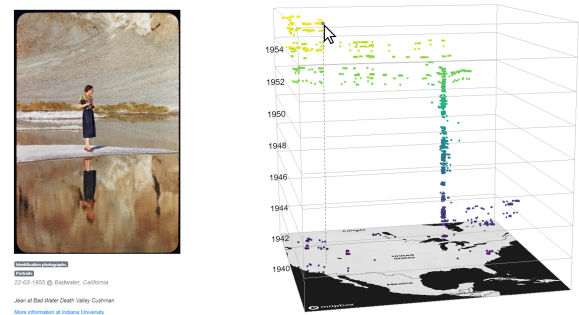

Figure 4: Geographic space-time cube depicting Cushman's pictures as indicators of his travel activities from 1938 to 1955 with a close-up of his first wife Jean at Badwater, CA in March 1955.
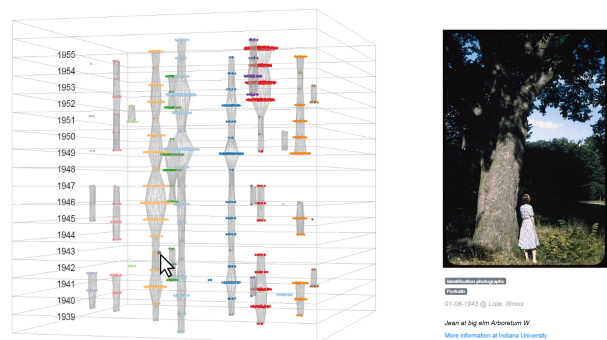

Figure 5: Categorial set-time cube depicting the development of photography genres within the Cushman collection from 1938 to 1955 with a close-up of an identification photograph of his wife Jean in an arboretum at Lisle, IL in August 1943.

and in several road trips explored the surrounding regions and national parks, during which Cushman took the picture of Jean in Badwater, CA (see figure 4, left).

Photography Genres

Figure 5 depicts a categorial set-time cube representation of the same corpus selection based on the primary genres of the photographs. The visualization shows that across all photographic categories, Cushman took the fewest pictures in the year 1943. Their number increased again over the following years, with an especially high number in 1952—the year the couple moved over to the west coast.

With an activated hull structure, the set-time cube makes the main subject of Cushman's pictures visible as they develop over time. While he took a wide variety of photographs before the shooting, the gaps in 1943 indicate that he took only "snapshots" (dark green in figure 5, "landscape" (red) and "identification photographs" (light orange, which also mainly contained plants and buildings) and did not regain his full variety until 1946. A category of photographs he hardly used after 1942 are "glamour photographs" (in light blue on the right in figure 5).

Similar to 1943, in the year 1948, a gap within many genres can be observed. Studying the archive's biography (In-
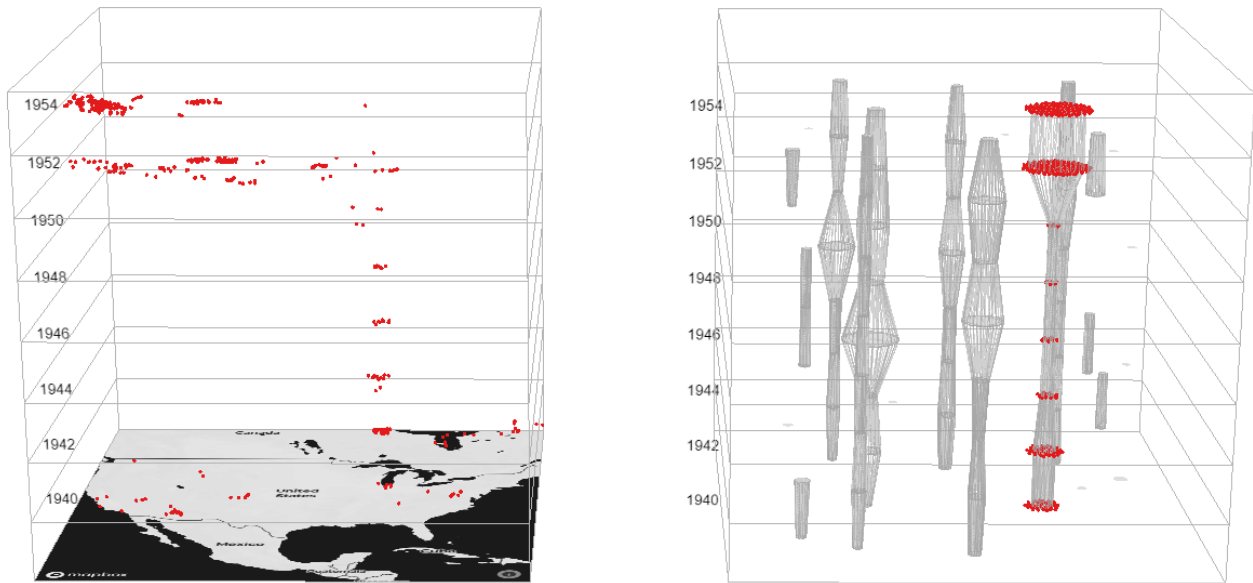
Figure 6: Combined geo- and set-time cube depicting the development of the genre landscape photographs.

diana University, 2017) and other publications (Sandweiss, 2007a; Sandweiss, 2012) we could not identify any critical events in Cushman's private or professional life that explain this temporal rupture. But the similarity of this pattern to the constellation in 1943 suggests, that another important event could have happened within this period that curbed his creative urge – and maybe also influenced his decision to take up his travel activities again in 1951.

Space, Time, and Genres

The PolyCube framework also offers a parallel setup of "coordinated multiple cubes", which allows to use the photographic genres as filters for the geo- and the set-time cubes to explore more specific questions. To illustrate this option, we took a closer look at landscape photographs that show an initial decline in numbers in 1942 and increase massively again in 1952 (Figure 6, right). Selecting this category we can zoom and filter on this subset of landscape pictures, and explore their spatio-temporal distribution (Figure 6, left). A large number of landscape photographs was taken at the West Coast especially in 1954 and 1952 as well as in the Middle West in those years. The amount of landscape photographs during Cushmans earlier years is linked to his travel activities as well. Doing the same analysis with other categories, we can deduce that Cushman took the largest number of architectural and cityscape photographs during his time in the Chicago area. Though this might not be surprising and evokes the image of a contemporary tourist, this analysis points to a simple fact: As Cushman was an amateur photographer the subjects he chose were not dependent on any professional focus or on his clients demands, but on his own interests. "*He crafted an extraordinarily complete inner world from the fragments of life that he found around him, a world defined more in terms of his own experiences than in the service of a search for a hidden essence or an unknowable design*"

(Sandweiss, 2012, p. 212). Additionally, he was wealthy enough to allow for extensive private journeys and used the opportunities provided by his travel activities to choose his motifs.

4. Discussion

With this paper, we explored the potential of a visualization method for time-oriented collection data to enrich the historians and biographers methods portfolio. Deliberately going beyond one-dimensional data portraits, it provides the means for an integrated "distant and close reading" inspection of large cultural collections from two time-oriented macroanalytical perspectives.

In a case study on the American amateur photographer Charles W. Cushman, we showed both how object data can fill in periods of lacking biographical knowledge, and more specifically, how the development of a collection could be inspected for consequences of critical life events—on a geographic and on a categorial level. We also discussed how the pictures show no direct connection to Cushman's professional life and rather appear as a resource for further exploration and understanding of his private life.

As with many case studies in the digital humanities realm, we consider the results to indicate a possible general application area, while remaining a local exploration until further notice. Obviously, due to the idiosyncratic data structures in historical fields of study, the analytical avenues generated in this case study cannot be directly transferred to other archives or other people's lifework collections. However, due to the wide-spread use of temporal, geographic, and categorial descriptors, we consider the PolyCube framework to be provide a relevant macroanalytical extension for biographical research. Distant reading or viewing approaches like the ones discussed in this paper offer dynamic overviews on large archival collections.

These representations again enable users (1) to identify and interpret basic patterns within a lifework collection on an macroanalytical level and (2) to identify objects of interest for more detailed investigation, e.g. with traditional art-historical, formal, or also critical-interpretative means.

4.1 Limitations

Visualizations obviously depend on *digitized content* and can represent only those events of a biography, where corresponding data or documents exist already in a digital format. Thus, for the purpose of extended biographical research, our inspected data selection (from 1938 to 1955) would require a substantial extension — for example, with information on events which happened before and after our archival sample. Also information on critical life events might have been omitted from the official biography on purpose – and thus would require additional investigation and corroboration.

We consider the added value of visual analytical approaches to historical records to generally hinge on a minimum level of data quality and data specifity. Only very few historical object or lifework collections lend themselves as a completive source for the creation of high resolution portraits. For this purpose, only specific artifact collections provide either detailed or consistent enough documentation in multiple metadata dimensions (such as on time of origin, place of origin, category) for each object. From a generalization point of view, this is no negligible restriction, as only modern technologies generate these inscriptions reliably by themselves (e.g., digital photography)—and only few artists pay attention to meticulously document the circumstantial or contextual conditions of their creations.

In all other cases, *uncertainty* and *incompleteness* of collection data is a major challenge—and visualization has to find new ways to cope with these standard conditions of historiographic data – and the humanities' knowledge consistency in general (Windhager et al., 2018a). Some of the main uncertainty types encountered in the Cushman collection include blurry dates of origins (e.g., time periods of many months), missing or imprecise location (e.g. "United States"), and photographs assigned to no or multiple genres. Techniques which we applied to deal with uncertain categorization included a "no category"-category, which holds all images without a genre, and to visualize intersections between the genres to also show more complex affiliations to primary *and* secondary genres (Salisu et al., 2019). Many further techniques to encode temporal, spatial and categorial uncertainty are available (Windhager et al., 2018a), but designers of visual-analytical systems will also be well advised, to find elegant trade-offs between the wide-spread omission of uncertainty - and the imminent risk of overburdening interfaces with visual complexity.

Moreover, caution and special expertise are needed when interpreting digital collections of photographs as historical documents both from a distant and close viewing perspective (Sandweiss, 2007b; Drucker, 2017). Close-up interpretation is well-known to be a multipolar process, where the meaning of an artifact is constantly co-constructed by historians, artists, and both their surrounding social and cultural contexts. On the aggregated, macroanalytical level, the digital remediation of photographs can lead to a loss of information in comparison to the original artifact or viewing context, and frequently also to a loss of critical hermeneutical distance (Drucker, 2013). Archives can be fragmentary or biased (e.g. based on the specific interest of the collector), and they frequently allow only a limited view on a body of work. Thus also visualizations should be explored with critical caution when biographical information is deduced, or even inspected for their invisible and un-seen parts (Glinka et al., 2015).

4.2 Outlook

Going one step further, biography visualizations (depicting a person's direct spatio-temporal trajectory like in figure 3) and lifework visualizations (depicting objects like in figure 4 and 5) could be beautifully combined, to shed light on each other. Future work on the PolyCube framework will aim for the simultaneous and consistent visualization of both types of complex dynamics – which will also help to avoid the visual inconsistencies between representations building on different software packages (cp. figure 3). In our analysis of the Cushman collection, we found it very useful for our interpretation of his lifework to relate the photographs to events in Cushman's life. But at other points, we figured that the lifework collection can provide us with information going beyond the biographical knowledge – for example, giving more detailed information on his travel activities or changes in Cushman's photographic interests, which could hint at another (yet unknown) critical event in his life.

We consider such contextually rich and transactional approaches to interpretation to be of relevance in multiple history-oriented knowledge domains. Even ongoing debates with proponents of a "New criticism"-style focus on objects or "texts themselves" seem to benefit from the emergence of these novel methodological options, as they help both micro- and macroanalytical sides to redefine and recalibrate their positions – including the development of research programs which systematically aim to intertwine and mediate the best of both interpretive worlds (Hickman and McIntyre, 2012; Drucker, 2017; Jänicke et al., 2015).

Our presented visualization approach could also be extended for prosopographical research purposes to combine, contrast, and compare the lifeworks of multiple persons of interests. A planned extension of the PolyCube framework with a relational space-time cube (to represent time-oriented graphs) could further visualize objects as links between multiple persons (like documented by their correspondence, or also by shared portraits) in combination with their geo-temporal and categorial-temporal patterns. Such a multi-perspective, tri-partite visualization framework could further be enriched with the aligned representation of textual biographical accounts. Geo-time cube, set-time cube and net-time cube then can mutually re-contextualize a source text, and thereby instantiate a multimodal, narrative framework of biographical knowledge exploration and communication.

5. Acknowledgements

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