Algorithmic Exhibition-Making
Curating with Networks and Word Embeddings

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The practice of curating art has evolved significantly over the past two decades, moving away from a focus on objects towards a thinking in networks. This shift is informed by Joasia Krysa's theory of 'distributed curating' and 'networked co-curation', in which art curators act as nodes in complex network structures (Krysa 2006; Graham/Cook 2010). Contemporary art curators also speak of networks and now understand their own activities as 'a way of thinking in terms of interconnections: linking objects, images, processes, people, locations, histories, and discourses' (Lind 2010).

Network science is a multidisciplinary field that provides a comprehensive framework for analysing, modelling, and understanding the complexity of interconnected systems (Barabási 2016). Based on principles from graph theory, network science studies the structural and dynamic properties of various networks of nodes (people, objects, concepts, et cetera) and edges (links, connections, relationships). By applying network science to curatorial practice, various network analysis methods and graph algorithms can be used to probe and visualize digital collections. These methods enable curators to identify patterns, arrange nodes into meaningful groups, and navigate the latent spaces of digital collections.

Word embeddings are numerical sequences, or vectors, that encode the meaning of words, for example, based on their contextual use in a text corpus. Based on the linguistic 'distributional hypothesis' (Harris 1954), word embeddings presume that

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words in similar contexts have similar meanings. Word embeddings use deep learning algorithms such as word2vec (Mikolov et al. 2013) to learn dense, distributed representations of texts without supervision. In the resulting multidimensional embedding space, similar vectors are closer to each other. To quantify the similarity between word embeddings, it is possible to use distance metrics such as cosine similarity, which measures the angle between two vectors. This facilitates a comparison of word meanings and the identification of semantically related words or concepts within the embedding space, thus giving rise to a range of natural language processing applications. In the museum context, Flexer (2021) demonstrates the use of word embeddings to enrich collection metadata so as to discover semantically related artworks. Integrating network science and word embeddings into the curatorial context enables curators to better understand and engage with art collections. This integration fosters the creation of insightful, semantically coherent exhibitions, and demonstrates the potential of network science as a valuable tool for contemporary curatorial practice.

Case Study

ARCU&OHM is a human-machine collaboration with the objective of developing computational methods and tools for curatorial tasks. ARCU (Artificial Curator) was initially developed in 2016 as an artistic project to create an expert system capable of autonomous research in the field of art for future curatorial projects. As part of the *KUNST(re_public)* art exhibition at HALLE 14—Center for Contemporary Art Leipzig, ARCU&OHM created an algorithmically curated exhibition (HALLE 14 2021). The exhibition took place from 20 June to 30 August 2020 and featured eleven works from the inventory of the acquisition awards of the Cultural Foundation of the Free State of Saxony. Building on the premise of this experimental project, we explore the potential of word embeddings and network science for synthesizing specific curatorial strategies and selection processes. This initial approach demonstrates the practical application of computational methods in the field of exhibition-making and art curation.

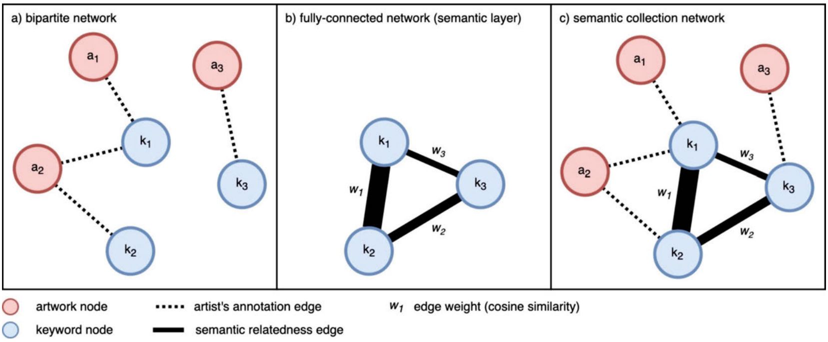
Collection Data

The Art Fund of the Free State of Saxony provided metadata on 376 artworks (including multipart series) from its annual acquisitions between 2011 and 2019. All the works are part of the collection of the Staatliche Kunstsammlungen Dresden. The original artists already provided annotations for their artworks using 565 German keywords describing a variety of different concepts, objects, and locations (e.g., 'alienation', 'innovation', 'mining', 'polar bear', 'computer', 'East Germany'). Altogether, the selection included 1609 keyword annotations, which are highly individual and sometimes reflect very specific interests. The supplementary word associations based on ConcepNet Numberbatch (Speer et al. 2017) complement the collection data to some extent, but also cover more general relevant dimensions of meaning.

Network Construction

We began by constructing a network from the collection data, with keywords and artworks as nodes and annotations as edges. This bipartite network (two distinct sets of nodes with connections solely between the sets) is poorly connected due to the unsystematic use of multiuser-defined keywords (fig. 1a). To create a meaningful semantic structure, we enriched the data with multilingual precomputed word embeddings from ConceptNet Numberbatch (Speer et al. 2017). This model encapsulates a general lexical meaning space of word associations and was state-of-the-art for the German language at the time of the project.

Figure 1: Network construction process: a) bipartite network with artwork-keyword pairs from the artists' annotations, b) fully-connected network of keyword-keyword pairs with edge weights from the cosine similarity of their word embeddings, c) the final semantic collection network.

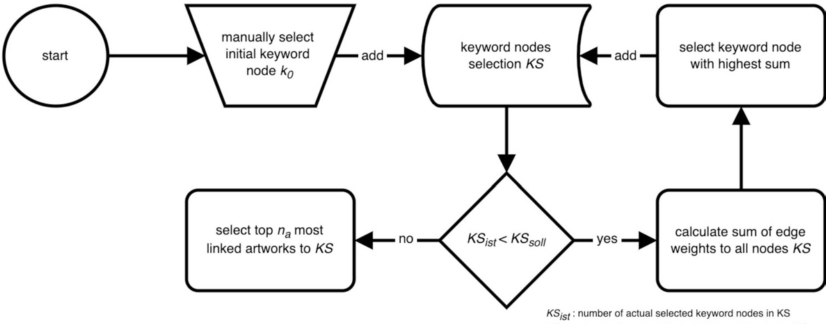


For our extended collection network, we computed cosine distances between all the keyword-keyword pairs based on their respective word embeddings. This fully connected network, which consists of edges between keywords with their cosine similarity as weights (describing the strength of a connection) represents the 'meaning association layer' (fig. 1b). Consequently, similar terms in the network are mapped with a stronger relationship in comparison to less closely related terms. For example, in our model, the keywords 'religion' and 'bible' have a cosine similarity of 0.45317942, while the keywords 'forest' and 'digitization', by contrast, have a similarity of -0.008358647.

Selection Process

To emphasize the exploratory nature of our algorithmic approach, we opted to initiate the selection algorithm with just one keyword and let the iterative process evolve from there (see fig. 2).

Figure 2: Flowchart of the iterative selection process.



KS_{ist} : number of actual selected keyword nodes in KS
KS_{soll} : targeted number of selected keyword nodes in KS
n_a : number of artworks

This simple algorithm starts with a manually chosen initial keyword node k_0 and iteratively adds relevant keyword nodes to the keyword selection *KS* based on their edge weights (sum of edge weights to all nodes in *KS*). Once the desired number KS_{soll} in *KS* is reached, it chooses the top n_a artworks with the most links to all nodes in *KS*. This approach enables the algorithm to explore and select relevant artworks for the exhibition based on the evolving connections between the selected keywords without leaving the broader theme of the initial keyword.

The curator of Halle 14, Michael Arzt, chose 'Gesellschaft' (society) as the central theme of the exhibition and limited the topic space to a maximum of 15 keywords. The desired output length was set to 20 artworks. Upon requesting the selected artworks from the Kunstfonds of the Free State of Saxony, we received confirmation that eleven of the 20 works would be available for loan during the period of the exhibition. After reducing the collection network to the available artworks, we used the Louvain method (Blondel et al. 2008) to identify discrete communities of more closely associated themes. Three main communities were thus considered as subtopics of the exhibition.

Exhibition Display

To visually represent the communities detected and to facilitate exhibition planning, we created three independent network visualizations using the ForceAtlas2 algorithm (Jacomy et al. 2014) and adjusted the layout to the floorplan of the exhibition space (fig. 3a). Each of the three networks represents a distinct community defined by specific artwork-keyword pairs. Here, each artwork appears only once, while keywords may recur in multiple networks. The final visualization served two functions: it provided a spatial reference for arranging the artworks in the exhibition space, and also offered a conceptual outline for visitors.

Figure 3: Exhibition display results. a) Network visualization on exhibition space floor plan [2] *b) Exhibition press photos: HALLE 14 | Walther Le Kon.*

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2 1) *Space-in-between*, Ya-Wen Fu, performance; 2) *Trust The Girls*, VIP (Lysann Buschbeck, Grit Hachmeister, Kathrin Pohlmann), video performance; 3) *PLONG*, Nori Blume, video installation; 4) *Laughing Inverts*, Lena Rosa Händle, photography; 5) **7. oktober 1977 Alexandria *1. Juli 2009 Dresden*, Susanne Keichel, photography; 6) *Untitled (crime dub)*, Mark Hamilton, video installation; 7) *Das deutsche Tier grüßt seinen Wald – no. 1*, Dominik Meyer, oil on canvas; 8) *Robotron—a tech opera*, Nadia Buttendorf, video; 9) *Ostdeutschlandfahrt (Goldrausch)*, Falk Haberkorn, photography; 10) *Triptychon: Revier*, André Schulze, oil on canvas; 11) *debris*, Martin Reich, photography.

Discussion

This project in 2020 made an early, original, yet fully streamlined attempt to incorporate networks and word embeddings into curatorial practice, with the goal of providing impulses towards algorithmically designed exhibitions. As an initial exploration, the case study demonstrated the applicability of these methods for navigating digital art collections and developing meaningful exhibition themes. Network visualizations served as practical planning tools and engaging conceptual references for visitors.

The resulting exhibition *KUNST(re_public)* at HALLE 14—Center for Contemporary Art Leipzig was perceived overall as coherent and made sense to the audience. However, it lacked the clear message or signature that a human curator typically communicates.

The objective was not to replace human curators, but rather to provide a starting point for discussing curatorial algorithms and for exploring the promising potential of human-machine co-curation through more sophisticated methods in the near future, while emphasizing the importance of maintaining a strong human presence in creating impactful exhibitions. More research in this area is needed to further explore these preliminary findings.

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