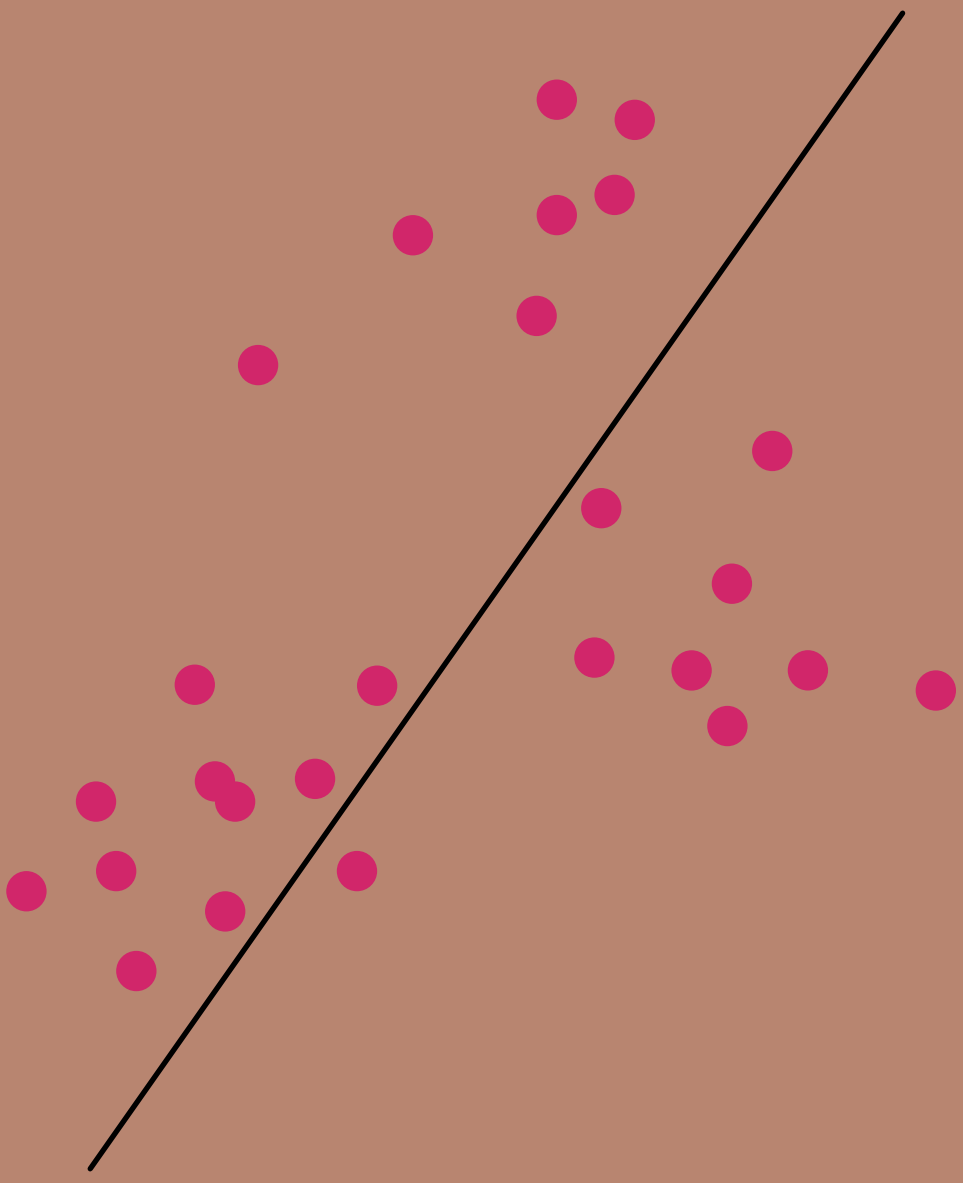
Training the Archive – Working Paper 3



Francis Hunger

Curation and its Statistical Automation by means of Artificial ‘Intelligence’

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Training the Archive

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Working Paper 3: Curation and its Statistical Automation by means of Artificial ‘Intelligence’.

> “I believe that museum curators should consider new ways of classifying and sorting information made possible by algorithms, as it is already part of their daily work and activities now that many museum collections have been digitalized and can be viewed and edited via collection management systems and software” (van der Vaart and Cruickshanks 2019, 4).

> “Indeed, curating has become a practice available to any user of mobile and networked technologies, while also any object, including a salad, is ready to be curated” (Tyżlik-Carver 2018, 191).

Abstract

The concept of post-AI curating discussed in this working paper explores curation as a knowledge-creation process, supported by pattern recognition and weighted networks as technical tools of artificial ‘intelligence’. The text discusses a number of concepts that build on each other, such as curating, curator, the curatorial, curatorial experimental research, post-human curating and post-AI curating. It then examines several projects as case studies that approach curation using artificial ‘intelligence’: *The Next Biennial Should Be Curated by a Machine* from UBERMORGEN, Leonardo Impett and Joasia Krysa (2021) as a meta-artwork about curation and biennials; Tillmann Ohm’s project *Artificial Curator* (2020), which resulted in an automatically curated exhibition; and *#Exstrange* by Rebekah Modrak and Marialaura Ghidini et. al. (2017), which presents artworks as data objects on the eBay online platform. Finally the text shifts to summarising embeddedness, big data infrastructures, spatiality and information model, solutionism and digital humanities, selection and similarity as instances of post-AI curating.

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1 Introduction

What remains of curation if the “next biennial”, as Joasia Krysa suggests, is “curated by a machine” (Krysa 2021)? Will the profession of curator continue to exist if we succeed in formalising and automating ‘creativity’? How does curatorial action change if, as van der Vaart and Cruickshanks propound, it automates questions of classification and sorting, i.e. curatorial knowledge creation, to a greater extent than before? What concept of curating art remains if we describe, as Tyżlik-Carver does, an expansion of the curatorial and concomitant reconfigurations of human subjectivities on digital platforms?

This paper serves to define the position of The Curator's Machine in the field of the curatorial. The Curator's Machine is a software prototype designed to take on curatorial tasks using pattern recognition and computer vision. The Ludwig Forum Aachen and the Hartware MedienKunstVerein Dortmund are cooperating on developing this prototype as part of the project Training the Archive.[1]

The aim of this text is to elaborate on current developments in the field of the curatorial that are entering our daily lives through the expanded statistical and automated capabilities of data processing by means of artificial 'intelligence'. For this purpose, a number of artistic, technical and curatorial projects are discussed as case studies: first a meta-artwork about curation and biennials from UBERMORGEN et al. *The Next Biennial Should Be Curated by a Machine*, second Tillmann Ohm's project *Algorithmic Art Curation* (ARCU), which translates data into spatial relationships, and third the curation of art for an online platform using eBay as an example. Similarities and differences will be filtered out from these case studies in order to fine tune the concept of post-AI curation.

First we must set down several preconditions to firmly define concepts such as: firstly, curation and curator, secondly, curatorial research, curatorial set and data sets, thirdly, automation of knowledge creation in curatorial software infrastructures, and fourthly, post-human curating and post-AI curating. These reflections are all to be read in the context of Training the Archive as we have created this present working paper as a component of this project. The project's goal is the artificial 'intelligence' software prototype The Curator's Machine, which visualises similarities and differences in art collections and thus becomes a curatorial tool. "The confirmation that machines could generalise the specific knowledge of curators of the collection of a museum invites us to consider a productive thought experiment. It is technically possible to store the annotations on the hidden connection patterns between individual artworks in an ANN [Artificial Neural Network] as a separate model, so that it can be continuously retrained with new expert knowledge, without losing the specific findings from the annotation work of the individual experts." (Bönisch 2021, 5.29).[2]

The participating project partners foster different curatorial cultures as the Ludwig Forum Aachen has its own collection and works with it, while the Hartware MedienKunstVerein Dortmund works without a collection and pursues questions on the social significance of art, particularly of media art (Daniels, Frieling et al. 2001).[3] The artistic director of

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[1] For more information, see the previous working papers: *The Curator's Machine. Clustering of museum collection data through annotation of hidden connection patterns between artworks* (Bönisch 2021) and *„Why so many windows?" – How the ImageNet image database influences automated image recognition of historical images* (Hunger 2021b).

[2] While Bönisch speaks of "Artificial Neuronal Networks", the present text employs 'weighted network' instead to dispense with the biological concept of 'neurons' and to de-anthropomorphise the methods of artificial 'intelligence'. At the same time, we write 'intelligence' in artificial 'intelligence' in quotes to indicate that it is not intelligence in the human sense but rather in the sense of detection that is being negotiated here. In some cases, we therefore also speak of 'automated statistics' or 'automated pattern recognition'. These linguistic corrections are preliminary suggestions, which the author is continuously developing.

[3] To keep the focus on questions of curation, this working paper avoids a more in-depth discussion of collecting, the creation of knowledge in the collected (cf. Foucault 1969) and the patriarchal and colonial reshaping of collection (cf. Clifford 1988; Mignolo 2003; Classen and Howes 2006; Azoulay 2019, Ch. 3). On the one hand, we would have to differentiate the collection from the archive. On the other hand, special genealogies of museum and custodial collecting would have to be elaborated, touching on classification, management and preservation (cf. e.g., Segelken 2010; Krajewski 2011).

the HMKV, Inke Arns, insists above all on contemporaneity as a central characteristic of media art, whereby the focus is not on technology but on its technological effects on society (Arns 2008). Does this result in project-relevant views of 'curation'?

One point is clear from the outset: artificial 'intelligence' is not a fundamental impulse that could 'revolutionise' or upend the field of curation, but it is a technical tool that may open up new ways of selection based on similarities, especially when applied to large amounts of data – big data. But selection, as we will see, is only a small component of the curatorial. This working paper therefore serves to probe and explore curatorial practices applied to digitised data collections.

2 From curating to post-AI curating

2.1 Curating and curator

Curating describes the working relationship between the curator and aesthetic objects and constellations in relation to artists, institutions, collectors, media, exhibition visitors, sponsors and exhibition logistics. The aim of curatorial action is to create situations that result in a specific public sphere for a limited period of time. This current concept of curating has emerged in several phases.

Beginning in the 18th century at the latest, curation was an inwardly directed, targeted engagement of institutions with their collection, aimed at completing, preserving and valorising that collection. This also included exhibition activity, which was closely linked to the institution. The Latin root curare refers to the aspect of 'looking after' and 'caring for', but also 'administering' and 'commanding'.

Since the 1960s, institutional critique (cf. Fraser and Dziewior 2003) and conceptual art processes (cf. Siegelaub 1971) have shifted perceptions of curation. Over time, questions of mediation, participation and the creation of contexts and new knowledge supplemented tasks such as collecting, preserving, arranging and exhibiting. Not until the end of the 1990s did 'the curatorial' begin to receive attention as a knowledge-producing field in its own right. (Krysa 2006, 14; Schafaff 2012, 136; Sternfeld 2012; Tyżlik-Carver 2018, 171). The term 'the curatorial' refers to the meta-level of curating, located in the academic context and dedicated to theorising the curatorial field.

In addition to these research tasks, the curatorial profession consists of a variety of coordinating practices, such as exhibition logistics, communication, funding and public relations, which are supported by corresponding infrastructural media (cf. Schüttpelz 2016).

Changes in curating went hand in hand with a differentiation of the related professional field of curator. Alongside institution-bound, permanently employed curators, protagonists appeared who worked as freelance and nomadic 'independent' curators. The latter often worked without a fixed collection. They brought the curated objects together for a limited period of time and then returned them to their diverse places of origin.

Despite the many changes in the role of the curator, we can observe one constant – curators are positioned as experts. The majority of currently active curators are academically trained, partly interdisciplinarily in the newly emerging curating degree courses[4] or, in the case of museums, disciplinarily in relation to the respective museum collection as an art historian or archaeologist, for instance (van der Vaart and Cruickshanks 2019, 8). From this, we can conclude that curating is always linked to expert knowledge. In curatorial activity, a distinction must be drawn between research in the academic sense and practice in the sense of

[4] Examples of curatorial degree programmes include: *École du Magasin Curatorial Studies* – Le Magasin (Grenoble), *Independent Study Program/Curatorial Program* – Whitney Museum of American Art (New York), *De Appel Curatorial Programme* – De Appel (Amsterdam), *MFA Curating* – Royal College of Art and Goldsmiths (London), *Kulturen des Kuratorischen* – HGB Leipzig, *PhD in Practice in Curating* – ZHdK (Zürich), *Curatorial Practice Program* – California College of the Arts (San Francisco, USA), *Center for Curatorial Studies and Art in Contemporary Culture* – Bard College (Annandale-on-Hudson, New York), *Curatorial Studies – Theorie – Geschichte – Kritik, Kunstgeschichtliches Institut der Goethe-Universität* (Frankfurt/Main), *Curatorial Studies* – KASK & Conservatorium (Ghent), and the *International Master's Programme in Curating Art* – Stockholm University (Stockholm).

coordinating practice (Fig. 1). The software prototype being developed in the scope of Training the Archive and discussed in this series of working papers serves as a research tool and is thus classified as part of the experimental research component of curatorial activity.

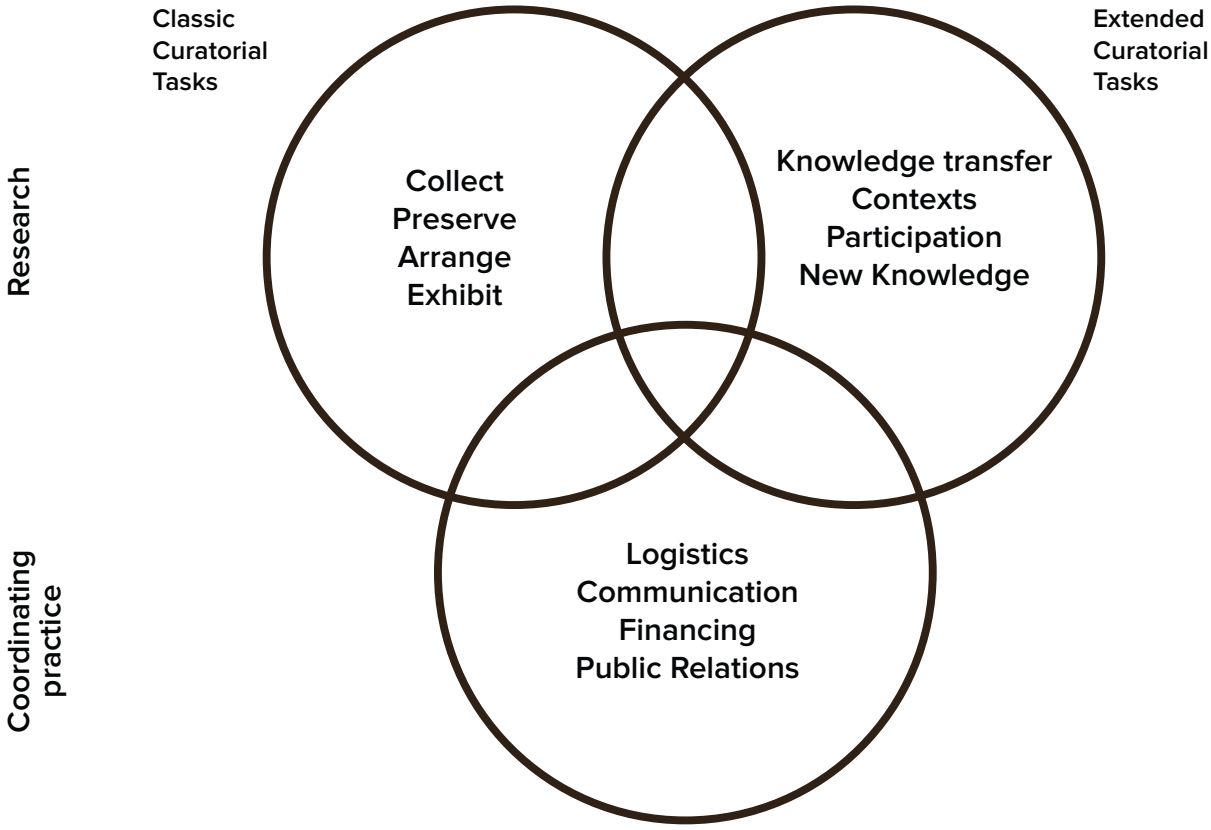

Fig. 1: The curatorial field: experimental research and coordinating practice. The classic curatorial tasks of collecting, preserving, arranging and exhibiting have expanded since the 1960s to include questions of knowledge transfer, contexts, participation and knowledge creation. Coordinating tasks such as logistics, communication, funding and public relations are part of curatorial professional practice (author).

2.2 Curatorial research and the curatorial set as a data set

In the text *Curating and Research – An uneasy alliance* Simon Sheikh focuses on curatorial research and establishes that two different meanings are embedded in the word 'research': firstly, research as the exploration of an area of knowledge in the journalistic sense, and secondly, research that follows a scientific approach. "If journalism understands itself as an endeavor that uncovers the truth by looking at the facts, and thus constructing a story, or what we can call a discourse, from what it finds, then science works, principally and traditionally, in the opposite direction – that is, from the discourse to the objects. Science implies a specific way of looking, through apparatuses of knowledge, as exemplified by the microscope and the laboratory, which also goes for ethnographic and sociological models of field research" (Sheikh 2019, 100f.). According to Sheikh, while journalistic methods present the results of their research as facts, experimental research treats its results as unsubstantiated concepts to be verified, which could confirm or falsify an initial thesis. In the case of falsification, questioning the research method itself and adapting it if necessary is part of scientific culture.

This results in the exhibition as a changeable laboratory situation in contrast to the archive as a place of research: "the historical similarities between the laboratory and the white cube of the gallery as spaces for isolated viewing and experimenting with objects are self-evident" (ibid., 110).

The concept of the curatorial set accompanies the laboratory character of curatorial experimental research. In the course of curatorial experimental research today, we create not only exhibitions, but also something that, according to the theorist Beatrice von Bismarck, can be described with the concept of the curatorial set, such as performances, installations, art in public space and similar settings that have the character of a laboratory. The curatorial set, a space or field that temporarily fixes exhibition objects in place, is akin to the data set. Data sets are characterised by their rigid and repetitive structure, so that in a data set the data retain an expectable location and become addressable. The way data is spatially organised in a data set or database can create meaning (Krämer 2010a, 2010b), just as the way objects are ordered in a collection case, in tables or in a curatorial set can create meaning.

The curatorial set and the data set are temporarily fixed until they are changed through practices of rearrangement. Both curatorial set and data set gain meaning through the positioning of the objects and through the relationships between the objects. Referring to a 1969 essay by the artist Dan Graham, von Bismarck speaks of subjects and materials as "in-formation", that is as arrangements of relationships that are in formations (Bismarck 2010, 54). Information as formation is a concept that media theorist Markus Krajewski similarly emphasised in the text *In Formation – Aufstieg und Fall der Tabelle als Paradigma der Datenverarbeitung* (*In Formation – Rise and Fall of the Table as a Paradigm of Data Processing*) (Krajewski 2007). This concept of information affects other media – databases usually structure objects in two-dimensional, relational data sets based on mathematical procedures for extracting information (Burkhardt 2015; Hunger 2022).

The classifying procedures of artificial 'intelligence' span via weighted networks a multi-dimensional space in which graphs and vectors spatially represent knowledge and knowledge relations: "The operational power of machine learning locates data practice in an expanding epistemic space. The space derives, I will suggest, from a specific operational diagram that maps data into a vector space. It vectorizes data according to axes, coordinates, and scales. Machine learning, in turn, inhabits a vectorised space, and its operations vectorise data" (Mackenzie 2017, 51).

An information model establishes the relationship between reality and machine computation in the computer. The information model determines which data are included in the reality of computing and which data are excluded from it. To illustrate, the table header is an information model par excellence, as the column labels determine which data are collected from reality and transferred to the data space of the table and which are not.

Do these similar spatial methods result in a transferability of curatorial settings into the formatting and formalisation of databases or the pattern recognition of artificial 'intelligence'? If so, this would pave the way for replacing curators with software.

2.3 Curatorial software: automating knowledge creation

If one views the exhibition space as a laboratory, the question arises as to how these laboratories and, above all, curatorial workplaces are equipped. We will not discuss this in its entirety here – the spatial situation of white cube or urban space and so on have been examined elsewhere (cf. O'Doherty 1986; Deutsche 1996). Nor should there be any talk of bookshelves, desks and similar office furniture, binders full of documents and receipts or the inevitable

coffee machine (cf. Meynen 2004; Krajewski 2011). Instead, the discussion here is focused on the software tools of curatorial work that are assembled in the office.

Following the subdivision mentioned above, the coordinative practice includes calendars and transaction tables for logistics and process control, mathematical tables for financial calculation, address databases for artists, and press work and communication software such as e-mail, messenger and social media. Artificial 'intelligence'-based text tools such as the proofreading software Grammarly or translation tools such as DeepL or Google Translate are also increasingly used.

Tools for research and investigation include knowledge tables in Microsoft Excel, word processing programs such as Word and Open Office, search engines such as Google, or VuFind in libraries, object and material databases such as LIDO and MuseumPlus, software for 3D visualisation of exhibition spaces such as SketchUp or Blender, and more recently big data or pattern recognition (artificial 'intelligence') procedures. This results in figurations of the most diverse software, some of which merge into one another and are used as modules (cf. Manovich 2013, especially pp. 113–123), even if they were not originally designed to be modular.

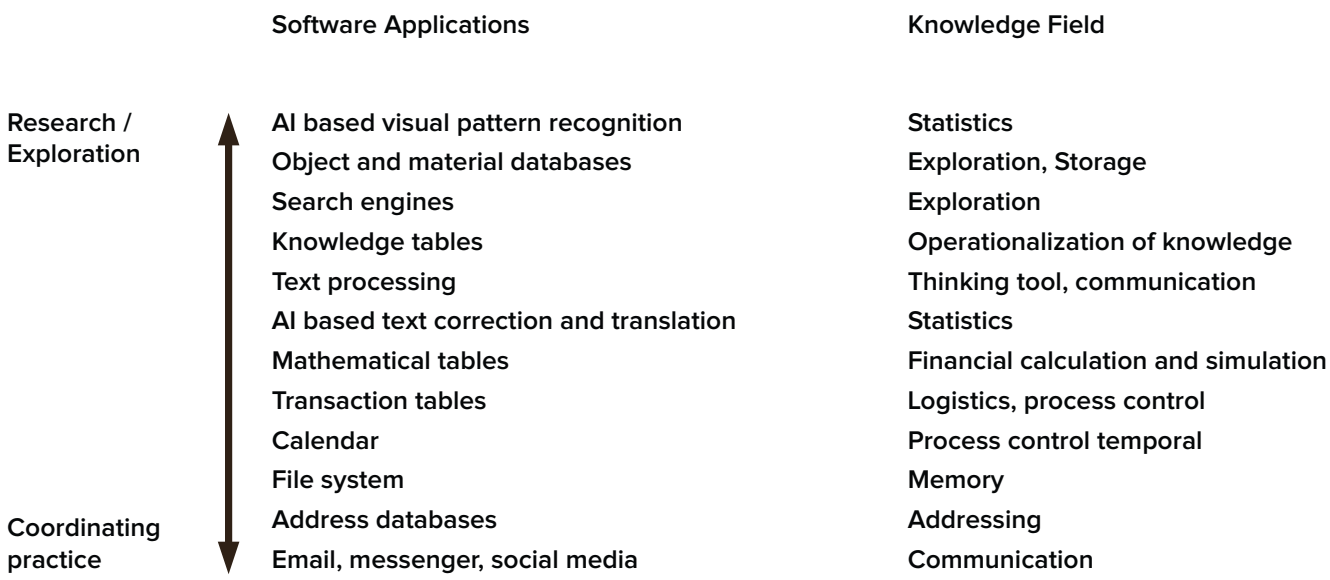

Fig. 2: Software figurations of curating between research/information gathering and coordinating practice. (author).

In this context, software figurations refer to the layers of different software that build on each other, such as the Windows operating system, which carries the Excel program, or the Linux operating system with the Python programming language, which allows the Keras programming library to be used for machine learning tasks. This software embodies and enables the execution of cultural techniques of knowledge creation that are typical for curation. They are part of the invisible infrastructure (Bowker et al. 2010) of curating.

The motivation for using software is to operationalise and automate knowledge creation. Automation is not meant here in the sense of full automation, but always as partial automation of those areas that can be sufficiently abstracted and formalised so that they can be encoded in software.

Automation: An example is the Excel table, which can be sorted both by date and alphabetically. In this context, sorting by software is understood as an automated operation

on data because it does not have to be done 'by hand'. Instead an algorithm such as bubble-sort automatically changes the order of the entries. The operation 'Sort' allows two different knowledge-creation modes in one and the same table space: a temporal sort and a topological sort. If software such as Excel with its algorithmic sorting functions was not available, this process would have to be carried out laboriously by brain and hand as in the past. In this respect, we should not regard the use of artificial 'intelligence', i.e. complex, automated, statistical operations, as a break with previous knowledge-creating operations, but rather as a continuation of them. Curatorial practice thereby moves through a series of fields of knowledge and a series of medial automating practices within the framework of software applications, as the diagram above illustrates (Fig. 2). These medial practices are among the invisible infrastructures of curating.

Embeddedness: Curator's Machine becomes part of the research infrastructure and is embedded in other knowledge-building processes and cultural techniques. Thus, a number of scripts are used to prepare the data, but also spreadsheets or database applications. The pattern recognition software itself is based on a complex software ecology that includes languages such as Python and R as well as versioning, in Git for instance, or setting up virtual environments, Jupyter notebooks and the libraries needed for machine learning such as Keras or Pytorch, all the way to cloud offerings such as Google CoLab.

Big Data: The Curator's Machine's visual pattern recognition is suitable for big data approaches, i.e. researching large amounts of data. The prerequisite for big data is a digitised institutional collection. The big data approach of The Curator's Machine reaches its limits with smaller exhibition venues, art associations, galleries and off-spaces, which rarely have extensive collections of their own. After all, big data requires large amounts of data. Small institutions thus depend on external data sets to enrich their own data sets. However, adopting external data sets also entails adopting external collection logics, and it is important to consider to what extent they are in line with one's own principles.

Replication of framing, exclusions and biases: The methods of The Curator's Machine are linked to the digital humanities, which aim to make digital methods productive for the social sciences.[5] However, the authors of The Curator's Machine are aware of the danger of merely digitally replicating the existing canon by drawing on existing collections. A knowledge tool like The Curator's Machine is, for instance, unable to remedy the exclusions or biases inherent in collections. Thus, existing framings of own and third-party collections are also imported into the big data data sets used in the context of pattern recognition. One can use this in the context of curatorial experimental research to make corresponding exclusions visible and point out epistemic gaps. In this context, we do not view gaps as something absent or missing, but as something inviting us to fill them with knowledge.[6]

However, whether or not the knowledge gained about exclusions leads to consequences in the collections depends not on the software, but on the institutional framework and the actors in the institutions.

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[5] For a critique of epistemological procedures in the digital humanities, see, among others: *Where Is Cultural Criticism in the Digital Humanities?* (Liu 2012); *Neoliberal Tools (and Archives) – A Political History of Digital Humanities* (Allington, Brouillete and Golumbia 2016). If one follows the argumentation in *Generative Digital Humanities* (Offert and Bell 2020b), the digital humanities are not only characterised by the application of digital methods to social science fields, but also by reverse interventions from the social sciences into the media-technical discourse of digital tools.

[6] The working paper *"Why so many windows?" – How the ImageNe image database influences automated image recognition of historical images* (Hunger 2021b) investigates the framings, biases and exclusions already embedded in the pre-trained networks of pattern recognition using ImageNet as a case study.

2.4 Post-Human Curating und Post-AI Curating

What theoretical concept can describe the shifts in curating that are becoming inevitable with the emergence of artificial 'intelligence' or pattern recognition? We will discuss this below using the concepts of post-human curating and post-AI curating.

Post-Human Curating: Digitally automated methods of knowledge creation, which also include pattern recognition procedures, have become commonplace. These may include recommendations on YouTube that lead from one video to the next 'similar' video and create similarities through machine 'learning' (cf. Titlow 2015; Chaslot 2017; Chun 2018) or the facial recognition functions built into smartphones that focus on faces, identify people when taking photos and arrange the photo album accordingly, or automatically change photos by means of pre-trained weighted networks and turn photography into "computational photography" (Steyerl 2014). These methods are based on the statistical evaluation of large amounts of data and the automated attribution of similarity. Objects that are similar to each other are grouped together and generate a 'similarity knowledge'.

Similarity is a fundamental property of automated, statistical pattern recognition, as media theorist Wendy Chun explains using the term 'homophily'. Homophily describes the tendency of people to approach other people who are similar to themselves in behaviour and habitus. Data doubles can be used to map homophily online, and, as Chun describes, this results in numerous consequences. "Homophily reveals and creates boundaries within theoretically flat and diffuse networks; it distinguishes and discriminates between allegedly equal nodes: it is a tool for discovering bias and inequality and for perpetuating it in the name of 'comfort', predictability, and common sense" (Chun 2018, 62). In this text, we will use the term 'similarity', which is broader and more oriented towards artificial 'intelligence' methods than the concept of homophily, which refers to humans. The mapping of supervised learning, which uses mathematical methods of classification and regression, can be described as the production of similarities. Similarity is a fundamental argument of artificial 'intelligence'.

For this shift media theorist Magdalena Tyżlik-Carver has proposed the term post-human curating.[7] Tyżlik-Carver noted that content curation is performed equally by human and non-human agents (e.g. software figurations, data, databases, APIs, artificial intelligence). "These are mundane practices where free digital labour is executed as linking, liking, reposting, aggregating, editing, filtering, semantic analysis, tagging and annotating, all of which are performed by people (individuals and communities, curators and users), software and social and technological platforms" (Tyżlik-Carver 2018, 171f.). Tyżlik-Carver's concept of post-human curating extends beyond the pure art context when she also describes these curatorial practices in, for instance, the social media context. According to Carver, the self/subject is represented by data, which on the one hand makes it addressable and exploitable. On the other hand, the data curators themselves determine, by means of their curatorial practice, which data come into circulation, and in this way they generate an "affective data body" (ibid., 185).[8]

Her argumentation is interested in the intertwining of human and non-human actors (e.g., recommendation algorithms on YouTube or Amazon), and such considerations are

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[7] Also compare the experimental forms of collective, networked curating in the 1990s as discussed in *Software Curating – The Politics of Curating in/as (an) Open System(s)* (Krysa 2008, especially pp. 72–76) and *Art Platforms and Cultural Production on the Internet* (Goriunova 2013).

[8] The idea of the data body refers to the data double, a concept introduced in the text *The Surveillant Assemblage* (D. Haggerty and Ericson 2000) to describe the mirroring of subjectivity and corporeality in databases.

also relevant for the present text. In order to further refine the conceptualisation, we will introduce the idea of post-AI curating as a subset of the concept of post-human curating and discuss it in relation to the project Training the Archive and The Curator's Machine.

Post-AI Curating: To supplement Tyżlik-Carver's concept, we propose post-AI curating in this context as an automating, knowledge-creating process of curating (art), which, in addition to coordinating processes (e-mail, calendars, financial plans, etc.) and knowledge-creating media such as databases, also includes techniques of pattern recognition, so-called artificial 'intelligence'. It is located within the investigative component of curating and here above all in the field of research in the sense of archival research, although its use in laboratory-like exhibition situations – and thus according to Sheikh's distinction in the field of curatorial experimental research – is also possible.[9]

Regarding post-AI curating, we should distinguish between the knowledge-creating processes of formalising curatorial decisions in databases and in artificial 'intelligence' applications. While databases allow the filtering, ordering and combining of data sets by means of queries/searches, pattern recognition can reconstruct data sets by means of algorithmic, generative procedures through spatial reorganisation (of the data vectors). Databases use reference to establish a traceable connection between the original object and the data extracted from it. For example, the attribute 'colour' exists in a given data set and for each data object this attribute is described with a discrete value ('red', 'yellow', 'green') that refers to the original object. It follows that queries to databases can only be made if the querier knows which attributes are specified in the database in the first place. Thus, there is also a clear relationship between inclusions and exclusions. All attributes defined for the database are part of the information model and everything that is not defined as an attribute of an object is excluded. Knowledge of the information model is already assumed in the queries, for instance: "Show me all objects from the data set that have the colour 'red'" (SELECT object FROM collection WHERE colour='red').

In contrast to this referential knowledge creation, the epistemic process of pattern recognition/artificial 'intelligence' is primarily based on the principle of homophily or the statistical similarity of the data objects to each other. Due to the complex mathematical and algorithmic processes that are active in the weighted networks of artificial 'intelligence' that span thousands of nodes, the internal workings of artificial 'intelligence' become a black box. Input and output can be observed, but the inner references are only perceptible to a limited extent. Human intervention mediates the weights within weighted networks in an iterative process of backpropagation (i.e., the feedback between output and the individual network nodes). However, it is not possible to predict the status of individual nodes. In contrast to the two-dimensional data objects of the database (represented as a table), the data objects in pattern recognition can be multi-dimensional. This enables a more complex aggregation of data that can map patterns that cannot be mapped in databases.

In contrast to the database, which is characterised by references, the principle of similarity rules in the field of artificial 'intelligence'. Data objects that are similar to each other are positioned in spatial proximity to each other and this spatial positioning is the pattern that makes a statement about the data set. The main statements of statistical pattern recognition are statements about similarity/dissimilarity of the data objects in relation to each other.

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[9] Post-internet art describes art that no longer understands the Internet as something new, but as a given (McHugh 2011; Olson 2011). In a similar sense, one could also speak of post-AI curating.

Fig. 3: Grid plot – passage from one image to another image based on the similarities of the adjacent images (Bönisch 2021).

Therefore, on the one hand, the framings of the data set become extremely important, because a changed data set produces different similarity ratios, and on the other hand, the methods of weighting in the weighted networks become important, because they also affect the similarities. The Curator's Machine takes advantage of this by allowing curators to change the weights based on visual examples, creating individually weighted networks that are intended to assess individual decisions statistically.

However, there is an inherent problem. Since, as shown, weighted networks lack references between data objects and their underlying real-world objects, they can inadvertently generate false similarities. For example, a person assessing several objects for similarity may intend the similarity of two objects to be based on the colour 'blue'. However, the weighted network does not comprehend this criterion as a selector for similarity. It only receives that two selected objects are similar to each other. It doesn't create a concept why and how something was deemed similar by humans. Since similarity is inscribed in weighted networks using mathematical-algorithmic procedures, namely by optimising the mathematical function, shortcuts may occur. In the case of texture bias (Geirhos et al. 2019; Geirhos et al. 2020), the weighted network perceives the criterion of similarity to be texture and not the similarity of colour that the humans actually intended.[10]

In addition to the aspect of similarity, post-AI curating as a field of knowledge creation is also marked by a series of topoi that are decisive for automated statistics of pattern recognition (aka artificial 'intelligence') even beyond curating:

- 'Intelligence' occurs as a statistical grouping of similarities (cf. Chun 2018) that remain within a specific domain of knowledge. The inherent relationality of the processes of artificial 'intelligence' promotes homogenisation, as relationships are calculated from the proximity of objects to each other.
- Cultural artefacts are encoded into data doubles and in the process trans-coded and formatted (D. Haggerty and Ericson 2000; Manovich 2001, 43–48). Detection and classification is carried out through discretisation (cf. Bowker and Star 1999; Steyerl et al. 2018; Eubanks 2019) and is subject to a whole series of abstractions.

[10] For more information on texture bias, see the working paper *"Why so many windows?" – How the ImageNet image database influences automated image recognition of historical images* (Hunger 2021b).

- The generation of new, similar artefacts from existing data corpora is possible (cf. Offert and Bell 2020b) and further complicates the question of the 'authenticity' of data bodies.
- Normative, data bias and algorithm bias constantly need to be renegotiated (cf. Noble 2018; D'Ignazio and Klein 2020; Offert and Bell 2020a).
- Automated knowledge-creation tools draw on data based on expended human labour (cf. Couldry and Mejias 2019; Hunger 2021a).
- Human-posthuman entanglements take place in complex infrastructures. Artificial 'intelligence' is *embedded* in socio-technical figurations (cf. Hayles 2005; Bowker et al. 2010).

The point here is not to claim that the referential logic of databases is superior or inferior to the non-referential similarity of pattern recognition. There are different and justified application cases for both. Instead, this distinction was drawn in order to clarify what may constitute the difference between post-human curating and post-AI curating – the transition from reference to similarity.

3 Case studies

The following case studies illuminate facets of the curatorial in relation to artificial 'intelligence' according to the topoi of post-AI curating listed above.[11] They discuss the potentials of generative processes of artificial 'intelligence' for curatorial action using the example of an algorithmically generated biennial, an exhibition curated primarily by algorithms, and the online platform eBay as an exhibition setting and curatorial tool. The focus is always on human-post-human curatorial interplay.

UBERMORGEN's art project *The Next Biennial Should Be Curated by a Machine* shows what happens when weighted networks and generative methods based on an existing corpus of data are used. At the same time, it is a deeply sceptical comment on the strategies of curatorial experimental research, which brings knowledge into specific arrangements and establishes it as a public discourse. By taking automation to the horizon of knowledge creation, confined by the knowledge domain of a (curatorial) data set, the artists show its limits.

What can post-AI curation look like? Tillmann Ohm's project *Automated Curator* (ARCU) investigates the extent to which curatorial decisions can be automated using artificial 'intelligence'. Can machines replace curatorial decisions in post-AI curating? Based on available meta-data and a curatorial set theme, a selection oriented towards similarities was presented. ARCU problematises the fact that automated knowledge formation tends to establish similarity as an unconscious normative. Although 'similarity' creates coherence, there is also a certain lack of tension, as we will see.

The exhibition project *#Exstrange* represents the concept of post-human curating. In this project, curating extends from the exhibition space to the online world, which artificial 'intelligence' recommender systems co-configure. *#Exstrange* turns the trading platform eBay into a laboratory of curatorial experimental research. This case study shows how the status of artworks is transformed into data bodies in a data-driven exhibition platform.

3.1 Meta-artwork on curating and biennials: *The Next Biennial Should Be Curated by a Machine* by UBERMORGEN, Leonardo Impett and Joasia Krysa (2021)

Based on data from previous major art exhibitions at the Whitney Museum for American Art and the Liverpool Biennale, this net art and machine learning project created a set of 64 potential biennials. This case study illustrates the transition from feature detection and classification using pattern recognition to generative methods. It shows that the existing data corpus itself is already fiction because it represents a conscious or unconscious extraction from reality. This data corpus was subjected to automated feature detection and classification using algorithms, weighted networks and pattern recognition. UBERMORGEN take the fiction of the underlying data corpus to the extreme by generating a new biennial from it.

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[11] However, we omitted a number of projects due to lack of space. These include, for instance, the exhibition project Data/Set/Match at the Photographers Gallery 2019-2020 as part of the larger research project *Unthinking Photography* (https://unthinking.photography/themes/data-set-match). The artistic project Computed Curation by designer Philipp Schmitt is a book that shows a sequence of images selected with the help of a weighted network. Peter Bell and Fabian Offert's project ***https://imgs.ai*** develops an open-source software with a web interface for the comparative finding of images in data sets. The central function is the inclusion or exclusion of sample images which serve as a basis for refining the search set.

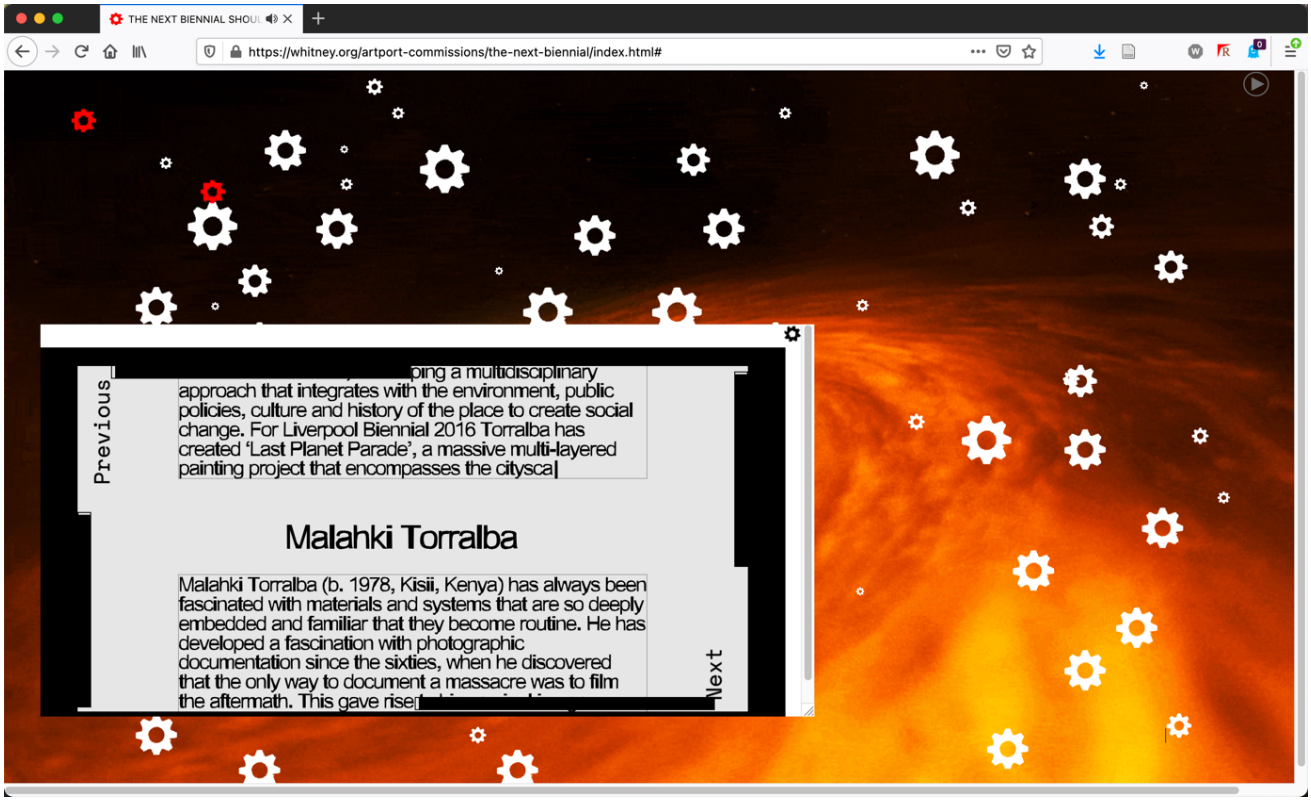

Fig. 4: UBERMORGEN et. al.: The Next Biennial Should Be Curated by a Machine (Screenshot)

The data pool consisted of exhibition descriptions and Excel lists of artwork data. From this, an assemblage of scripts, algorithmic processes and data sets called B³(NSCAM) generated potential biennials including fictitious artists generated from the data. A linguistic model based on the generation of word-level prediction was used for the text descriptions. This procedure calculates the subsequent word from a previous word based on statistical probability and generates an entire text this way, word by word. According to Christiane Paul, who was involved in the process as a curator on the part of the Whitney Museum, the curatorial texts thus generated sounded extremely academic. To remedy this, they decided to add articles from *Rolling Stone* magazine as a further data source in an attempt to subvert the curatorial jargon[12] of the original data sets (Cascone 2021). In a further step, the generated texts were combined with pop-cultural references, such as music by Black Pink, Toones & I, Lady Gaga and other chart and trap sounds, as well as with sound bites from TikTok videos. Shifting visual patterns that refer to vernacular do-it-yourself aesthetics of the 1990s and op-art served as the pictorial background.

Clicking in *The Next Biennial Should Be Curated by a Machine* website on a gear wheel icon (which typically symbolises "default settings" on computer interfaces) opens a modal window with the respective biennial. After the introductory text generated by the B³(NSCAM) algorithm, a list of artists appears, consisting of fictitious names and generated biographies. Here is an excerpt from the biography of the 'artist' Macy-Grace Laning: "Macy-Grace Laning (b. 1998, Citrus Park, United States) lives and works in New York, USA. Today, Laning studies the architecture of institutions such as prisons, mental hospitals, juvenile detention facilities, residential jungles, as well as fictional alien worlds. Her projects highlight

[12] On curatorial language see further *International Art English: On the rise–and the space–of the art-world press release* (Rule und Levine 2012).

the symbolic value of space as an arena for human interaction and action, and her fascination with the colonizers and their fetish for extraterrestrial technology" (UBERMORGEN, Impett, Krysa, et al. 2021). Using similar curatorial jargon, curatorial statements, reviews, and press releases were generated for each of the 64 biennials.

All in all, the artificial 'intelligence' component, i.e. all the automatically generated elements programmed by Leonardo Impett on the basis of the pre-trained weighted network for text processing GPT-3, makes a rather depressing and repetitive impression. The artistic positions and curatorial statements generated in this game become interchangeable modules that can be combined with each other at will.

UBERMORGEN comment that it will be "… the fluid biennial, the multiverse of all possible biennials displayed as an excerpt. The project is actually more a representation of the failure of current curation models than a radical reinvention or interpretation of curation" (Bernhard 2021, e-mail). Their work further opposes a development in curating that increasingly turns artists into "suppliers of semi-finished products" (ibid.) that are reassembled at will by curators in exhibitions and biennials.

Since the present text has thus far been characterised by a rather unbroken relationship to curating, we shall quote a longer excerpt from UBERMORGEN's lecture event at the Digital Curator Symposium Brno as a more sceptical voice: "If machines and institutions are synthetic curators, and existing human curators replace traditional artists, as a consequence, technical systems and institutions automatically become dominant. If all these systems feed on the 'curated' systems or sources, for example Google rankings, Wikipedia entries, and Artfacts lists, informational incest becomes the new gold (Ether) standard. Abusing contemporary fields of societal negotiations such as inclusion, diversity and bias and rendering these transformative issues into institutional PR narratives. Polishing and streamlining language to intersect while gaslighting audiences trained in populism and consumerism, incapable of processing uncomfortable realities, facing painful contradictions; and scared to cause inconvenience for corporate sponsors" (UBERMORGEN 2020). UBERMORGEN's tastefully selected pieces of music and animated image backgrounds work against the statement clutter generated by artificial 'intelligence' (with partial human intervention). The humanly curated selection ultimately makes the project a meta-artwork that can be encountered according to human standards in the sense of enjoying art.

3.2 Arrangment based on similarity: *Artificial Curator* by Tillman Ohm (2020)

Artificial Curator (ARCU), a project by artist Tillmann Ohm, takes semantic similarities in metadata as the starting point for pattern recognition. It shows how 'similarity', as a guiding principle in post-AI curating, can lead to the homogenisation of results and their banalisation.

Metadata are data that people (title, dimensions, material, etc.) and also machines (location, date, type of device, etc.) have assigned to the digital image data object in the course of digitisation. A weighted network helped to calculate contextual associations between the metadata. For this purpose, Ohm chose the pre-trained ConceptNet Numberbatch, which maps word embeddings as semantic vectors.[13] Vectors are mathematical constructs

[13] Numberbatch is built using an ensemble that combines data from ConceptNet, word2vec, GloVe and Open Subtitles 2016, using a variation on retrofitting. It is described in the paper ConceptNet 5.5: An Open Multilingual Graph of General Knowledge, presented at AAAI 2017. Unlike WordNet, it was designed to be multilingual from

that make it possible to express 'distance' and 'direction' by specifying at least two points. By linking meanings to vectors, it is in principle possible to make the relationship between words mathematically processable.

Fig. 5: View of the exhibition ARCU, Halle 14, Leipzig 2020 with Nadja Buttendorf *Robotron – A tech opera*, 2018; Dominik Meyer *Das Deutsche Tier grüßt seinen Wald*, 2009 and Martin Reich *debris*, since 2013 (Walther Le Kon/Halle 14).

The ARCU project resulted in the installation of 'curated' artworks in an exhibition space, as well as a website user interface that presented the relationships of the works of art to one another. For *Artificial Curator*, the Art Fund of the Free State of Saxony provided the Dresden State Art Collections including the meta-data of 365 artworks that entered the collection between 2011 and 2019 as part of the subsidised acquisitions of contemporary art from the Federal State of Saxony. Michael Arzt, curator of the Leipzig art space Halle 14 where *ARCU & Ohm* 2020 was exhibited, set 'Society' as the thematic focus.

Starting from this keyword, semantic relationships between the artworks were organized in clusters. No additional adjustment to the pre-trained ConceptNet Numberbatch weighted network was made. The selection was condensed down to 20 works of art based on the shortest pathways to the keyword 'society'. The Dresden State Art Collections ultimately made 11 of these works available for the exhibition.

After completing the selection process, the question was how to present the works in the space. For this purpose, Tillmann Ohm used ConceptNet Numberbatch to create new clusters from the works' meta-data and transferred them into spatial relationships on

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the start. From version 17.04, which was released in 2017, the developers corrected bias and stereotypes they detected in the word contexts (cf. https://blog.conceptnet.io/posts/2017/conceptnet-numberbatch-17-04-better-less-stereotyped-word-vectors/).

the floor plan of the exhibition hall. Thus, this translation of semantic into spatial relationships, usually performed through human curatorial practices, took place in a human-machine figuration.

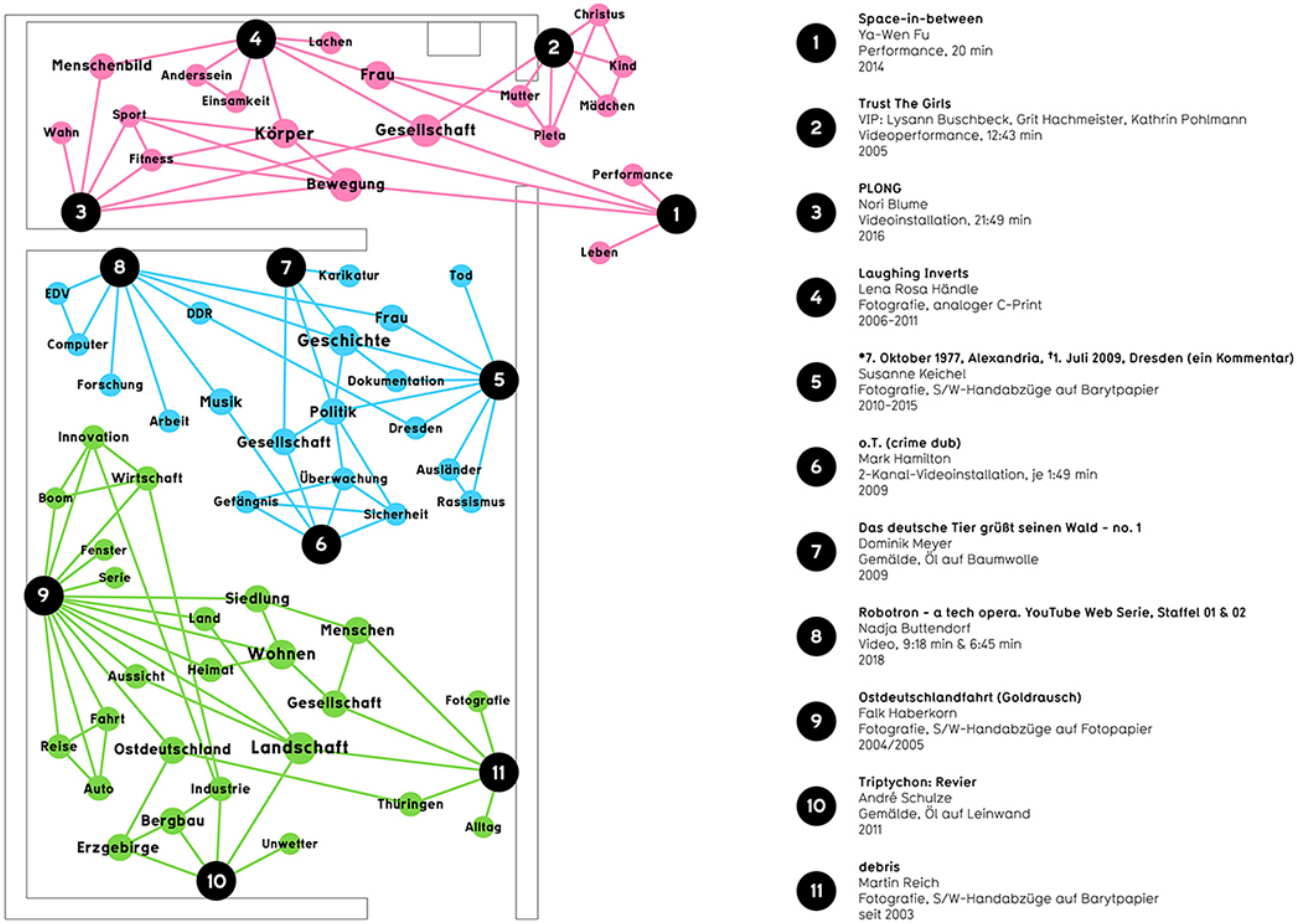

Fig. 6: Scheme of spatial distribution and content mapping in the ARCU & Ohm project (Ohm 2020).

Curation by means of artificial 'intelligence' in ARCU is limited to the computational tracking of the vectorial relationships of data objects in latent space. This is delimited by a specific domain of knowledge, in this case the 300 works of the Dresden State Art Collections or their metadata, which serve as material to which statistical operations were applied. Artificial curatorial 'intelligence' is embedded in a whole range of software artefacts such as databases, table-structured file formats for data exchange, graphics and image processing, and generative depiction techniques of network visualisation for the web browser.

One problem, according to Ohm, is that ARCU relies heavily on similarities in the data. The danger, explains Ohm, is that the selection will lack underlying tension because the selection criteria are based on similarities and the short distances of the data objects in the latent space. Objects that are similar to each other run the risk of levelling out and harmonising precisely those differences that make an exhibition exciting in the first place. This problem can possibly be mitigated if the underlying big data data set is as extensive as YouTube's databases, for example. At least the recommendations there based on the homophily principle are not boring, even if they are lacking in tension.

The majority of the works that ARCU chose from the Dresden State Art Collections are two-dimensional: photographs, drawings and paintings. In line with Andrea Fraser's reference to Martin Kippenberger "Kunst muss hängen" ("Art must hang") (cf. Graw

2001), the majority of the works were designed to be hung on walls and only two, both video works displayed on monitors, were suitable for sculptural installation in the room. On the one hand, this 'bias' refers back to the 'bias' that already exists in the underlying collection itself, but it also marks the difference to human curators. The latter would have had the opportunity to look outside the scope of the Dresden State Art Collections for works on "society" that do not hang in order to organise the space in a more balanced way.

3.3 #Exstrange: Curating for a platform – eBay and artworks as data objects by Rebekah Modrak and Marialaura Ghidini et al. (2017)

#Exstrange (short for "Exchange with Stranger") is an exhibition that replaces a gallery space with eBay as a platform. In this case study, the artworks become data objects that are initially designed to be data-processable. What appears here as an art project points to a fundamental predicament of digital humanities projects – the type of data logic, the so-called information model, formats the possible results. In #Exstrange, the logic of the database (of eBay) is at issue, which is indicated, among other things, by the fact that the contributions must fit into a predefined category logic.

In contrast to the aforementioned projects, which were interventions in existing collections, #Exstrange was conceived as a curatorial experiment and thus as curatorial experimental research, in which the main curators Rebekah Modrak and Marialaura Ghidini invited a number of artists and other co-curators. It joins a series of similar experiments on the eBay platform, such as John D. Freyer's *All my Life for Sale* (2000), Kembrew McLeod's *Selling my Soul* (2000), Mendi and Keith Obadike's *Blackness for Sale* (2001) and Ubermorgen's *The Sound of eBay* (2009). The aim was to interact with the platform's predefined algorithmic configuration and explore its possibilities and limitations. The platform provided the structure of the exhibition, as the artworks were to be classified into sales categories such as 'electronic devices', 'services' or 'collectors' items'. Curators and artists perceived this structure and the description opportunities via titles, labels, prices and images as an explicit part of the artistic works (Modrak/Ghidini 2017).

One of the co-curators, Gaia Tedone, observed how curatorial procedures had become embedded in the eBay platform: "There is even an Office of the Chief Curator, which selects the most interesting, story-worthy and spectacular items on eBay" (Tedone 2017). Tedone emphasised eBay's search function called Cassini, in particular, and how it demands 'best practices', i.e. high quality photographic images, appealing titles and detailed descriptions from sellers/artists. She, therefore, referred to the search function as the "Commodities Chief Curator" (ibid.).

In addition to the categorical functions of the database, eBay's platform ecology is characterised by search functions and recommendation components based on AI procedures (Sanjeev 2019). Due to the requirements of the eBay platform, commercial aspects clearly dominate the organisation of knowledge, which is structured along the lines of automatability and searchability by product categories. The project demonstrates how the logics of reference and the artificial 'intelligence' logics of similarity intertwine in a higher-level user interface.

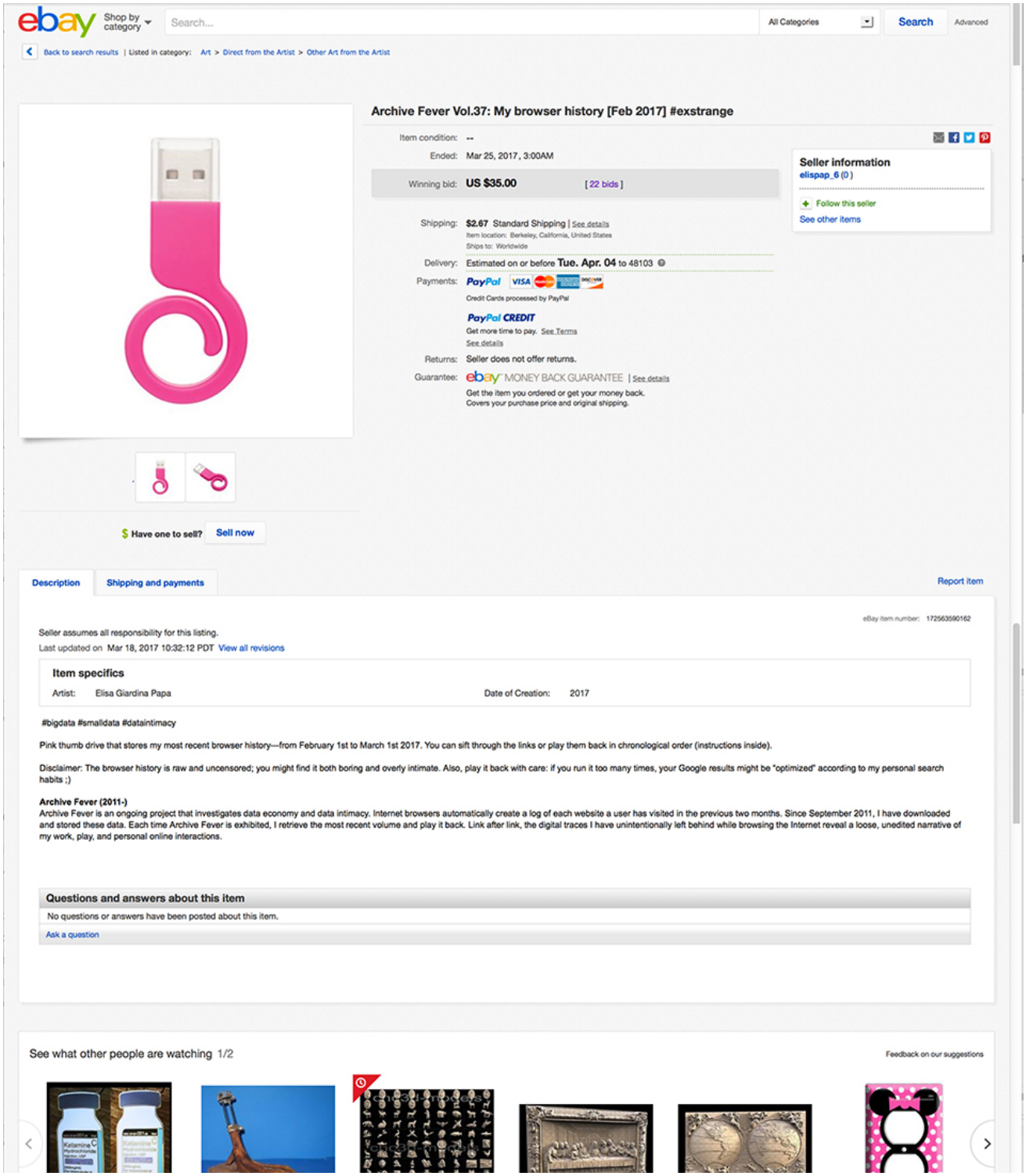

Fig. 7: Elisa Giardina Papa: Archive Fever Vol. 37 – My Browser History [Feb 2017] is an example from the #Exstrange exhibition on eBay (Screenshot from *http://exstrange.com/auctions/archive-fever-vol-37-my-browser-history-feb-2017/*).

4 Conclusion

The case studies have shown a number of consequences tied to artificial 'intelligence' procedures: similarity, selection, embeddedness, big data, spatiality and information model, solutionism and digital humanities.

Embeddedness: As shown, curators use an entire range of automating software tools in the curatorial process, including search engines, spreadsheets, word processing, calendars and storage solutions. These software-data figurations automate existing cultural procedures and knowledge fields of administration, logistics, knowledge organisation and process control. The curatorial artificial 'intelligence' of The Curator's Machine should be understood as part of these software-data figurations. Ruhleder and Star have identified *embeddedness* as an essential quality of infrastructure (Star and Ruhleder 1996, 113). It follows that the prototype of The Curator's Machine should take embeddedness more strongly into account than before, by expanding the possibilities for importing and exporting data, for instance.

Big Data Infrastructures: Methods of curatorial pattern recognition reference corpora of artistic works and large amounts of data. They are mostly limited to use in large institutions with their own collections due to the big data approach. The methods are in part computationally intensive and complex and require their own infrastructures and personnel. These must be developed anew in a resource-intensive way for each pattern recognition project – a strategic factor that makes the further spread of artificial 'intelligence' applications in small and medium-sized institutions difficult. By comparison, spreadsheets, e-mail programs or databases are easy-to-implement digitisation measures. This leads to the need for a civil artificial 'intelligence' infrastructure, which does not yet exist, and which should be requested from state and non-state actors – a kind of non-commercial CoLab.

Spatiality and Information Model: The translation of vectors from weighted networks into spatial relationships has thus far only been rudimentarily investigated (i.e. without automated transfer into 3D spatial models) and can be worked on further experimentally. The fact that both curatorial sets and data sets are spatially organised suggests overlaps between these two knowledge-creating cultural procedures. However, this would require more research into the possibility of modelling exhibition spaces.

Solutionism and Digital Humanities: Engineering-solutionist perspectives on data objects oversimplify complex curatorial strategies, reducing them to technical solutions. Rather than discussing increasing the amount of data as a solution, for instance, we should consider abstaining from or foregoing pattern recognition procedures in favour of other experimental research methods. This is something the technological sciences could learn from the human sciences: "We both – and everybody that has been involved in such [curatorial] practices – have been in a situation where we've had a concept that has been unmanageable and unrealizable", according to curator Irit Rogoff (Rogoff and Bismarck 2012, 24).

Selection: Exploration and selection in existing, large data sets, which The Curators Machine promises to automate, makes up only a specific component of curatorial experimental research and coordinative practice. Training the Archive and the projects listed here, which are dedicated to the corpora of archives, have thus far been oriented towards selection; that is towards a – compared to the participatory-, discourse- and education-oriented approaches of curating – rather traditional notion of curating. Artificial 'intelligence' procedures oriented towards similarities limit the knowledge potential to a specific domain of knowledge.

They run the risk of producing homogenous results, lacking in tension. We need to evaluate whether this problem can be counteracted a) in the algorithmic process and b) in the user interface and c) by integrating it into participatory, discourse- and education-oriented curation processes.

Similarity: Pattern recognition is a promising method for assigning similarity to data objects. Backpropagation can control this assigning indirectly, but the reference to the original objects is lost in complex weighted networks. The internal workings of the weighted networks become a black box. Since mathematical optimisation sets the weights within the networks, the training processes tend to calculate short cuts, such as texture bias, which undermine human intended ontologies and classifications. Using similarity procedures pushes the in-depth analysis of individual works into the background, because the objects or artworks are positioned solely according to an internal relationship, in other words, all of what is already in the data set. The knowledge generated in this way is necessarily relational and runs the risk of depoliticising the object of study.

We can summarise the curating and statistical automation using artificial 'intelligence': the concept of post-AI curating comprises curating in the field of art as a knowledge-creating process, supported by pattern recognition and weighted networks. The Curator's Machine as well as the projects *Artificial Curator* and *The Next Biennial Should Be Curated by a Machine* are rooted in the logics of curating in and with institutional collections. In contrast, *#Exstrange* shows the creation of curatorial sets as a curatorial experimental research outlined above. Can The Curator's Machine become more than the mere technological reawakening of social normatives embedded in the collections?

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Bibliography

Allington, Daniel, Sarah Brouillette, and David Golumbia. 2016. "Neoliberal Tools (and Archives): A Political History of Digital Humanities." Online Journal. *Los Angeles Review of Books*. May 1. https://lareviewofbooks.org/article/neoliberal-tools-archives-political-history-digital-humanities/.

Arns, Inke. 2008. "Und Es Gibt Sie Doch – Über Die Zeitgenossenschaft Der Medialen Künste." In *HMKV, Hartware Medienkunstverein, 1996-2008*, edited by Hartware MedienKunstVerein, Susanne Ackers, Inke Arns, Hans D. Christ, and Iris Dressler, 66–79. Bönen: Kettler.

Azoulay, Ariella. 2019. *Potential History – Unlearning Imperialism*. London/Brooklyn, NY: Verso.

Bernhard, Hans. 2021. "Re: Next Biennial (Training the Archive Text)," August 6.

Bismarck, Beatrice. 2010. "Relations in Motion. The Curatorial Condition in Visual Arts – and Its Possibilities for Neighboring Disciplines." *Frakcija Performing Arts Journal*, no. 55: 50–58.

Bönisch, Dominik. 2021. "The Curator's Machine. Clustering von Musealen Sammlungsdaten Durch Annotieren Verdeckter Beziehungsmuster Zwischen Kunstwerken." *Training the Archive – Working Paper, Aachen/Dortmund*, May. doi:10.5281/ZENODO.4604880.

Bowker, Geoffrey C., Baker, Karen, Millerand, Florence, and Ribes, David. 2010. "Toward Information Infrastructure Studies – Ways of Knowing in a Networked Environment." In *International Handbook of Internet Research.*, edited by Jeremy Hunsinger, Lisbeth Klastrup, and Matthew Allen, 97–117. Dordrecht: Springer Netherlands.

Bowker, Geoffrey C., and Susan Leigh Star. 1999. *Sorting Things Out – Classification and Its Consequences*. Cambridge, MA: MIT Press.

Burkhardt, Marcus. 2015. *Digitale Datenbanken – Eine Medientheorie Im Zeitalter von Big Data*. Bielefeld: Transcript.

Cascone, Sarah. 2021. "Who Needs a Curator When You Have A.I.? A Group of Artists Trained a Machine to Curate 64 Possible Whitney Biennials." *Artnet News*. May 6. https://news.artnet.com/art-world/ai-whitney-biennial-curator-1959025.

Chaslot, Guillaume. 2017. "How YouTube's AI Boosts AlternativeFacts." Online Publication. *Medium*. April 3. https://medium.com/@guillaumechaslot/how-youtubes-a-i-boosts-alternative-facts-3cc276f47cf7.

Chun, Wendy Hui Kyong. 2018. "Queerying Homophily." In *Pattern Discrimination*, edited by Hito Steyerl, Wendy Hui Kyong Chun, Florian Cramer, and Clemens Apprich, 59–98. Lüneburg: Meson Press.

Classen, Constance, and David Howes. 2006. "The Museum as Sensescape – Western Sensibilities and Indigenous Artifacts." In *Sensible Objects – Colonialism, Museums and Material Culture*, edited by Edwards, Gosden, and Philips, 199–222. Bloomsbury Academic.

Clifford, James. 1988. "On Collecting Art and Culture." In *The Predicament of Culture – Twentieth-Century Ethnography, Literature, and Art*, 215–51. Cambridge, MA: Harvard University Press.

Couldry, Nick, and Ulises Ali Mejias. 2019. *The Costs of Connection - How Data Is Colonizing Human Life and Appropriating It for Capitalism*. Culture and Economic Life. Stanford, CA: Stanford University Press.

D. Haggerty, Kevin, and Richard V. Ericson. 2000. "The Surveillant Assemblage." *British Journal of Sociology* 51 (4): 605–22. doi:10.1080/00071310020015280.

Daniels, Dieter, Rudolf Frieling, and et. al. 2001. "Media Art Net | Concept." Online Publication. *Media Art Net*. 2005. http://www.medienkunstnetz.de/concept/.

Deutsche, Rosalyn. 1996. *Evictions – Art and Spatial Politics*. Cambridge, MA: Graham Foundation for Advanced Studies in the Fine Arts, MIT Press.

D'Ignazio, Catherine, and Lauren F. Klein. 2020. *Data Feminism*. Cambridge, MA: The MIT Press.

Eubanks, Virginia. 2019. *Automating Inequality – How High-Rech Tools Profile, Police, and Punish the Poor*.

Foucault, Michel. 1969. *Archäologie des Wissens*. Frankfurt am Main: Suhrkamp.

Fraser, Andrea, and Yilmaz Dziewior. 2003. *Andrea Fraser – Works, 1984 to 2003*. Köln/New York, NY: Dumont.

Geirhos, Robert, Jörn-Henrik Jacobsen, Claudio Michaelis, Richard Zemel, Wieland Brendel, Matthias Bethge, and Felix A. Wichmann. 2020. "Shortcut Learning in Deep Neural Networks." *ArXiv:2004.07780 [Cs, q-Bio]*, May. http://arxiv.org/abs/2004.07780.

Geirhos, Robert, Patricia Rubisch, Claudio Michaelis, Matthias Bethge, Felix A. Wichmann, and Wieland Brendel. 2019. "ImageNet-Trained CNNs Are Biased towards Texture – Increasing Shape Bias Improves Accuracy and Robustness." *ArXiv:1811.12231*, January. http://arxiv.org/abs/1811.12231.

Goriunova, Olga. 2013. *Art Platforms and Cultural Production on the Internet*. New York, NY: Routledge.

Graw, Isabelle. 2001. “I Love Kippenberger. Andrea Fraser, Kunst Muss Hängen, Galerie Christian Nagel, Köln.” *Texte Zur Kunst* 11 (43): 156–60.

Hayles, Katherine. 2005. “Computing the Human.” *Theory, Culture & Society* 22 (1): 131–51. doi:10.1177/0263276405048438.

Hunger, Francis. 2021a. “Data Workers of All Countries, End It!” In *Hamburg Maschine – Digitalität, Kunst Und Urbane Öffentlichkeiten.*, edited by Isabella Kohlhuber and Oliver Leistert. Hamburg: Adocs.

———. 2021b. “‘Why so Many Windows?’ – Wie Die Bilddatensammlung ImageNet Die Automatisierte Bilderkennung Historischer Bilder Beeinflusst.” *Training the Archive – Working Paper, Aachen/Dortmund*, June. doi:10.5281/ZENODO.4742621.

———. 2022. “Die Form Der Datenbank – Genealogien, Operationalitäten Und Praxeologien Relationaler Datenbanken in Ost Und West.” Dissertation, Weimar: Bauhaus Universität Weimar.

Krajewski, Markus. 2007. “In Formation – Aufstieg Und Fall Der Tabelle Als Paradigma Der Datenverarbeitung.” In *Nach Feierabend: Zürcher Jahrbuch Für Wissensgeschichte – Datenbanken.*, 37–55. Diaphanes.

———. 2011. *Paper Machines – about Cards & Catalogs, 1548-1929*. History and Foundations of Information Science. Cambridge, MA: MIT Press.

Krämer, Sybille. 2010a. “Notationen Schemata Und Diagramme – »Räumlichkeit« als Darstellungsprinzip.” In *Notationen Und Choreographisches Denken.*, edited by Gabriele Brandstetter, Franck Hofmann, and Kirsten Maar, 29–45. Freiburg/Berlin/Wien: Rombach Verlag.

———. 2010b. “Zwischen Anschauung Und Denken – Zur Epistemologischen Bedeutung Des Graphismus.” In *Was Sich Nicht Sagen Lässt. Das Nicht-Begriffliche in Wissenschaft, Kunst Und Religion.*, edited by Joachim Bromand, 173–92. Berlin: Akademie Verlag.

Krysa, Joasia. 2006. “Curating Immateriality – The Work of the Curator in the Age of Networked Systems.” In *Curating Immateriality*, 1–25. Data Browser 03. New York, NY: autonomedia.

———. 2008. “The Politics of Curating in/as (an) Open System(s).” Dissertation, University of Plymouth. https://pearl.plymouth.ac.uk/handle/10026.1/326.

Liu, Alan. 2012. “Where Is Cultural Criticism in the Digital Humanities?” In *Debates in the Digital Humanities*. Minneapolis, MN: University of Minnesota Press. https://dhdebates.manifoldapp.org/read/untitled-88c11800-9446-469b-a3be-3fdb36bfbd1e/section/896742e7-5218-42c5-89b0-0c3c75682a2f#ch29.

Mackenzie, Adrian. 2017. *Machine Learners – Archaeology of a Data Practice*. Cambridge, MA: The MIT Press.

Manovich, Lev. 2001. *The Language of New Media*. Cambridge, MA: MIT Press.

———. 2013. *Software Takes Command – Extending the Language of New Media*. International Texts in Critical Media Aesthetics. London, New York, NY: Bloomsbury.

McHugh, Gene. 2011. *Post Internet – Notes on the Internet and Art*. Brescia: Link Editions.

Meynen, Gloria. 2004. “Büro.” Dissertation, Berlin: Humboldt-Universität zu Berlin. http://edoc.hu-berlin.de/dissertationen/meynen-gloria-2004-12-20/PDF/meynen.pdf.

Mignolo, Walter. 2003. *The Darker Side of the Renaissance – Literacy, Territoriality, and Colonization*. Ann Arbor, MI: University of Michigan Press.

Noble, Safiya Umoja. 2018. *Algorithms of Oppression – How Search Engines Reinforce Racism*. New York: New York University Press.

O’Doherty, Brian. 1986. *Inside the White Cube – The Ideology of the Gallery Space*. Santa Monica, CA: Lapis Press.

Offert, Fabian, and Peter Bell. 2020a. “Perceptual Bias and Technical Metapictures – Critical Machine Vision as a Humanities Challenge.” *AI & SOCIETY*, October. doi:10.1007/s00146-020-01058-z.

———. 2020b. “Generative Digital Humanities.” In *CHR 2020: Workshop on Computational Humanities Research*, 2723:202–12. Amsterdam: CEUR Workshop Proceedings.

Olson, Marisa. 2011. “Postinternet – Art after the Internet.” *Foam Magazine*.

Rogoff, Irit, and Beatrice Bismarck. 2012. “Curating/Curatorial.” In *Cultures of the Curatorial*, edited by Beatrice von Bismarck, Jörn Schafaff, and Thomas Weski, 21–40. Berlin: Sternberg Press.

Sanjeev, Katariya. 2019. “EBay’s Platform Is Powered by AI and Fueled by Customer Input.” Blog. *Ebay Tech*. March 13. https://tech.ebayinc.com/engineering/ebays-platform-is-powered-by-ai-and-fueled-by-customer-input/.

Schafaff, Jörn. 2012. “On the (Curatorial) Set.” In *Cultures of the Curatorial*, edited by Beatrice Bismarck, Jörn Schafaff, and Thomas Weski, 135–50. Berlin: Sternberg Press.

Schüttpelz, Erhard. 2016. “Infrastrukturelle Medien Und Öffentliche Medien.” *Media in Action (Pre-Publication)*, no. 0: 1–21.

Sheikh, Simon. 2019. “Curating and Research – An Uneasy Alliance.” In *Curatorial Challenges – Interdisciplinary Perspectives on Contemporary Curating*, edited by Malene Vest Hansen, Anne Folke Henningsen, and Anne Gregersen, 97–107. Routledge Research in Art Museums and Exhibitions, Volume 4. New York, NY: Routledge/Taylor & Francis Group.

Siegelaub, Seth. 1971. “The Artist’s Reserved Rights Transfer and Sale Agreement.” https://primaryinformation.org/files/english.pdf.

Star, Susan Leigh, and Karen Ruhleder. 1996. “Steps toward an Ecology of Infrastructure – Design and Access for Large Information Spaces.” *Information Systems Research* 7 (1): 111–34. doi:10.1287/isre.7.1.111.

Sternfeld, Nora. 2012. “What Can the Curatorial Learn from the Educational?” In *Cultures of the Curatorial*, edited by Beatrice Bismarck, Jörn Schafaff, and Thomas Weski, 333–44. Berlin: Sternberg Press.

Steyerl, Hito. 2014. “Proxy Politics – Signal and Noise.” *E-Flux Journal*, no. 60 (December).

Steyerl, Hito, Wendy Hui Kyong Chun, Florian Cramer, and Clemens Apprich. 2018. *Pattern Discrimination*. Lüneburg: Meson Press.

Tedone, Gaia. 2017. “Co-Curating with Cassini – From the Abyss of Commodification to the Exploration of Space Curation.” In *#exstrange – A Curatorial Intervention on Ebay*, edited by Marialaura Ghidini and Rebekah Modrak. Michigan, MI: Michigan Publishing. http://exstrange.com/.

Titlow, John Paul. 2015. “To Take On HBO And Netflix, YouTube Had To Rewire Itself.” Online Magazin. *Fast Company*. May 15. https://www.fastcompany.com/3044995/to-take-on-hbo-and-netflix-youtube-had-to-rewire-itself.

Tyżlik-Carver, Magda. 2018. “Posthuman Curating and Its Biopolitical Executions – The Case of Curating Content.” In *Executing Practices*, edited by Helen Pritchard, Eric Snodgrass, and Magda Tyżlik-Carver, 171–90. London: Open Humanities Press.

UBERMORGEN, Leonardo Impett, Joasia Krysa, and B^3(NSCAM). 2021. “The Next Biennial Should Be Curated by a Machine.” Artwork. https://whitney.org/artport-commissions/the-next-biennial.

Vaart, Merel van der, and Lorna Cruickshanks. 2019. “Understanding Audience Participation Through Positionality – Agency, Authority, and Urgency.” *Stedelijk Studies*, no. 8. https://stedelijkstudies.com/journal/understanding-audience-participation-through-positionality-agency-authority-and-urgency/.