METHOD IN INTERDISCIPLINARY RESEARCH: DATA SCIENCE FOR DIGITAL ART HISTORY

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ABSTRACT | This paper creates a conceptual frame and explanatory point of reference for the collection of papers presented at the exploratory workshop "Data Science for Digital Art History: Tackling Big Data Challenges, Algorithms, and Systems" organized at the KDD 2018 Conference in Data Mining and Knowledge Discovery held in London in August 2018. The goal of the workshop was to probe the field and to build a constructive interdisciplinary dialogue between two research areas: Data Science and Art History. The workshop's chairs and the authors of this paper share the conviction that Data Science can enrich art studies while analysis of visual data can have a positive impact on Data Science. Thus, the research initiative tried to critically reflect on the interdisciplinary collaboration between diverse research communities and its epistemological and ontological effects.

KEYWORDS | interdisciplinary collaboration, DAH community, methodology, data science, diversity, globalization, feature extraction, machine learning, deep learning

The Project Background

Recent years have seen a raising preoccupation with interdisciplinarity, which implies a variety of boundary transgressions, in which the strictly disciplinary knowledge systems are put aside.[1] These developments are observable in the rapid development of the field of Data Science, which emphasizes both algorithmic and methodological advances as well as expanding its interdisciplinary nature by exploring a plethora of application domains ranging from healthcare and cybersecurity to cultural heritage.[2] Interest in the application of computational methodologies to large-scale quantitative analysis of art have also been growing in Digital Art History. However, this rapid transformation and the visionary techno-optimistic discourse around Digital Art History require critical reflection. The call for critical Digital Art History has been growing in the last years. Most recently, in her review of the first issue of the International Journal for Digital Art History published in 2015, Claire Bishop observed that the theoretical problems and critical debates in Art History have been "steamrolled flat by the weight of data".[3] Scholars emphasize that the digital research of cultural heritage needs to be informed by professional art historical knowledge and rigorous scholarly methodology that acknowledges the mediation and situatedness of knowledge production. Otherwise, as observed by Anna Bentkowska-Kafel, it risks producing findings of uncertain cognitive value.[4] The prevalent focus on method instead of research question has also been critiqued by Paul Jascot in his review of the anthology Debates in the Digital Humanities published in 2012 and reissued in 2016.[5] Jascot argues: "The question is not what Art History can do with the digital; the question is what are the important art historical questions that can be addressed with the help of digital tools?"[6] Jascot calls for a Digital Art History that "[puts] the intellectual problem [rather than a method] at the center of the discussion." [7] There is little doubt that any research inquiry should be driven by a meaningful research question. But how do we build non-hierarchical relationships in the interdisciplinary collaborations between Art History and Computer Science if we tend to prioritize the research preoccupations of one discipline over the other? Is it the focus on the method per se, or the limited critical attention to that method that is to be blamed for the possible shortcomings of Digital Art History?

It is a matter of course that a method never exists a priori but is driven by our epistemological beliefs, which shape our research strategies. Hence, critical attention to method may in fact offer a fruitful path to engage with the critical debates in Art History and facilitate epistemological and/or ontological shifts in the discipline.

This premise is the point of departure for the research initiation project we embarked on in autumn 2017 and which brought together a specialist in Japanese early modern visual culture and a data scientist working on interpretable machine learning methods for spatial and temporal data. The project resulted in the exploratory workshop "Data Science for Digital Art History: Tackling Big Data Challenges, Algorithms, and Systems" organized at the KDD 2018 Conference in Data Mining and Knowledge Discovery held in London in August 2018, and this section of the International Journal for Digital Art History. In this short anthropological account of our collaboration we will briefly sketch the motivation and history of our research partnership, and reflect on its outcomes and future. The function of this account is to create a conceptual frame and explanatory point of reference for the collection of papers presented at our Workshop and published here. We hope that the results of our open-ended exploratory interdisciplinary collaboration between Art History and Data Science will provide useful insights into the state of the field, and will also inspire its critical evaluation, especially in relation to its yet to be fulfilled promise of a "foundational change, revolutionizing the discipline and its core practices" as pronounced by Johanna Drucker in 2015.[8]

One of the most important but not yet realized promises justifying the introduction of computational technologies to the Humanities, which would facilitate this change, was to get beyond the canon and recover a vast "slaughterhouse of literature" through distant reading, as proposed by Franco Moretti in 2000.[9] Although this initial ambition has been revised, it seems paradoxical that Digital Humanities and Digital Art History still have a problem with the canon. Instead of a pluralistic system of diverse cultural materials, canon establishes certain cultural phenomena as crucial, important and exemplary.[10] The issue is obviously larger than Digital Art History and pertains to the New Art History, which over the last forty years has dramatically shaken the canon but has not yet managed to completely dismantle the understanding of art produced in 1550 by Giorgio Vasari (1511-1574). The claim of the objectivity and universality of aesthetic judgement by Clement Greenberg (1909–94) continues to underline contemporary Art History which, as argued by Griselda Pollock, "is still centered around (white) men, still chronological, colonised, hierarchical, still largely oriented at classifying and labelling".[11]

The firm grip the idiom of the Great Masters has on the Humanities has been recently discussed among others by Laura Estill in relation to the prominence of Shakespeare in today's digital scholarship.[12] Rather than taking advantage of new technological solutions capable of revealing new patterns, connections and focal points, which can serve as a basis of constructing alternative historical narratives challenging the canon, digital projects often reify the centrality of certain figures. This is observable in literary studies and art historical discourse.[13] Particular choices of research material have obviously been motivated by different factors, not least related to research infrastructure, access to available data and funding, and are not guided by the intention to sacralize art.

However, these choices also have certain consequences when considered from the perspective of feminist and postcolonial studies, as they effectively contribute to the marginalization of certain social groups such as women, queer, or non-Western artists. Importantly, this situation has an impact on the development of computational technologies, which are customized to analyze certain types of materials and to perform specific analytical tasks, and may not be applicable in different research contexts and to related materials. Hence, the canon has proven extremely resilient to the impact of digital technologies. This is especially the case for non-Western art, which has received relatively little attention to date, especially in the Anglophone world. It is conspicuous that computational methods used in Digital Art History have not yet been customized to investigate many different types of non-Western cultural data. The epistemological diversity of world art has not yet been resolved by conventional Art History in its attempt to address the challenges of globalization and decolonization. The question of whether Art History is a global, non-hierarchical (rather than monocultural) field open to non-Western epistemologies and interculturation has been increasingly pronounced in the last decade, among others by James Elkins, Kitty Zijlmans and Wilifred Van Damme or David Carrier.[14] But even if World Art History is on the rise, these debates often develop as inside conversations largely limited to a few institutions in the South-Western context.[15] It is clear that if the study of individual objects identified as art through isolationist geopolitically-based narratives is replaced by critical computational analysis of visual culture at large, which can discover cultural patterns across geographical and chronological boundaries, a pluralistic Digital World Art History could have the potential to challenge the fundamental structures of power endemic to the canon.

Despite its currency, however, the potential of this concept has not been fully realized. Various factors are responsible for this situation, ranging from material

and financial conditions for research to the geo-politics of national identification and international relations. These developments raise the question of the operation of the method as a gatekeeping instrument and ethical consequences of our research practices. Before the digital revolution, gatekeeping was mainly associated with art institutions and certain professions including art historians, art critics, curators, collectors, the academy, museums, commercial galleries, art journals, etc. But as boldly proclaimed by Lamar Tyler in 2014, new technologies were expected to free us from the grip of these gatekeepers. [16]However, it is becoming increasingly clear that the selection of our research materials shapes the technological systems we build and use. In effect, instead of helping us to create the inclusive non-hierarchical pluralistic World Art History for which the call has been increasingly heard in the last decade, these systems tend to perpetuate existing epistemological paradigms while distracting us with the false assurance of openness, accessibility and horizontal approaches to material culture. Algorithms are not moral agents: they are as biased as their creators, and so recent years have seen the growth of discourse on ethical AI.[17] The main argument behind ethical AI is the fact that any machine learning or robotic framework relies on data generated by humans. If the data or the producers are biased, then the algorithm will build AI models that maintain the bias.[18] There have been several approaches to retrofitting existing AI methodologies via the new field of interpretable machine learning, wherein the key goal is to enhance capabilities of detecting and removing bias and provide explanations of predictions with statistical guarantees, as discussed by Marco Ribeiro and his colleagues, and Khuong Nguyen and Zhiyoun Luo.[19]

In sum, we realize that the computational instruments which often provide opportunities for innovation can also function to constrain it. The method, as part of a knowledge system, is always situated and never innocent. Therefore, the development of meaningful research questions also requires critical assessment of computational methods, especially in relation to their role in perpetuating or challenging the existing foundational premises of the discipline such as canon, which computational instruments were expected to help to dismantle. These observations can invite new critical analyses and innovative interpretations generated by interdisciplinary collaborations, which have the potential to transform the paradigms of Art History and Data Science. But for this to happen it is necessary to build credible and sound cooperation roadmaps that can tackle the methodological, theoretical and practical challenges involved in the task. Our collaborative research project was guided by this goal and therefore put the method in the center of the inquiry.

Collaborative Research Initiation Project

Critical reflection on the interdisciplinary partnership between Digital Art History and Data Science and the role of method in the process of reformulation of the existing paradigms of the two disciplines functioned as a point of departure of our collaborative research initiation project. They also underline the project's activities and venues, namely the organization of an exploratory workshop at KDD, a primary venue of technologists, which resulted in the collection of papers authored by the workshop participants, which follow this brief introduction in two examples.

The goal was to probe the field and to build a constructive interdisciplinary dialogue between two research areas: Data Science and Art History. The authors share the conviction that Data Science can enrich art studies while analysis of visual data can have a positive impact on Data Science. Recent advances in Data Science and machine learning research emphasize the need to explore, summarize, fuse, and learn from multiple, heterogeneous and complex data sources. The key methodology boils down to two angles of attack: (1) feature extraction and (2) model fusion. This gives rise to the recently emerging research area of multi-modal learning and multi-data fusion. The latter, empowered with modern deep learning algorithms, can lead to benefits in both Data Science and Digital Art History. First, the inherent complexity of the problems dealt with in Digital Art History, such as data intricacy over space and time, can give rise to novel data management and fusion approaches as well as new machine learning methods for knowledge extraction from Digital Art History sources. On the other hand, Digital Art History can directly benefit from Data Science by exploiting methods and techniques for significantly reducing manual labor, while obtaining new insights from the complex digital data sources as well as to generate a critical reflection on the discipline and its foundational assumptions. These premises were the foundation of our collaboration and the workshop we organized at the KDD 2018. The workshop highlighted challenges emerging from the encounter between the two disciplines and solicited papers that propose state-of-the-art solutions to practical and theoretical issues that arise from exploratory data analysis of large data sets of two-dimensional art, such as pre-modern East-Asian and Euro-American images (painting, prints, maps). As tackling relevant technological and theoretical problems requires divergent approach to science the workshop also was intended to provide space for critical reflection on our research processes.

As the field expands and Digital Art History-related research initiatives mushroom across academia especially in the Global North, it becomes clear that there is a need for

reflection on research processes as well as sharing good experiences and discussing pitfalls. Transparency of data and analytic practices is becoming the cornerstone of today's qualitative research in general, as it enables access to the evidence and interpretative process used to support empirical research claims. These issues have already been addressed, for example by the contributors of the volume edited by Anna Bentkowska-Kafel and Hugh Denard, who discuss the issue of transparency from a variety of perspectives reflecting theories and practices in different virtual heritage-related disciplines.[20] But as intellectual transparency is a precondition of valid research results it also showcases the importance of the method for the discipline at large.

Scholars responded to the call for methodological and procedural transparency and developed models of collaborations intended to overcome at least some of the challenges related to crossdisciplinarity collaborations between art historians and computer scientists. Only of few months ago a paper which exemplifies these efforts was published in this journal by Tracey Berg-Fulton and her colleagues.[21] Its publication coincides with our own research initiative and resonates with our study on several levels. We share the commitment to transparency and the visibility of research processes in relation to interactions between collaborators originating from different research fields. We also share intellectual preoccupations, especially with issues of scale and the relationships between close and distance reading. For us, the issue of scale does not only refer to the question of processing the large amount of data commonly practiced by Data Science and advocated by proponents of cultural analytics.[22] It also has wider ontological and ethical consequences related to the development of World Art History and feeds into a growing discourse on the role of machine learning and issues of social justice and human-centered AI exemplified by new research initiatives such as the Stanford Institute for Human-Centered AI or the WASP-Humanities and Society, a part of The Wallenberg Artificial Intelligence, Autonomous Systems and Software Program (WASP) in Sweden.

In their study, Berg-Fulton and her colleagues draw on their own research experiences to address challenges related to collaborations between art historians and computer scientists. They propose a particular model for collaboration based on the division of roles and factors that play the role in a successful collaboration. They conclude that although art historians and technologists occupy different problem spaces "they are not of necessity in opposition to one another".[23] Our research initiative is guided by a similar premise, but is based on a more open-ended approach grounded in the view that there is not now and never will be any one-size-fits-all model of interdisciplinary collaboration between Art

History and Computer Science, as the collaborative process is situated and develops through a variety of types and formats of interdisciplinary research.[24] Consequently, we decided not to follow a standard pattern of developing interdisciplinary collaborations, which usually begins with a specific research topic, formation of a research team, application for a research funds, and if successful, implementation of the project. Instead we probed the field first. There were different more theoretically oriented and pragmatic reasons for this. As research projects targeting non-Western visual cultures tend to exist on the epistemological and infrastructural peripheries of art historical inquiry they are also less visible in the mainstream discourse on Digital Art History. Hence, the goal was to identify researchers working on the projects that go beyond the mainstream, and also to connect directly to the community of Data Scientists not yet involved in the study of art. The workshop functioned as a test to see if they would be interested in engaging in new collaborations and projects within the scope of Digital World Art History and to contribute to the customization of computational instruments that would be useful in these particular projects. The KDD Conference on Data Mining and Knowledge Discovery—one of the major Data Science conferences with roughly three thousands participants from all over the world, including leading universities, research and industrial organizations—was a perfect venue to realize these goals. Moreover, the format of the KDD Workshop offers a unique opportunity to discuss novel ideas on current and emerging cross-disciplinary topics relevant to knowledge discovery and data mining, and engage a wide range of participants. This gives it the potential to lead to the development of cross-disciplinary collaborations resulting in the initiation of innovative research projects. Not surprisingly, the idea of combining Data Science with Digital Art History has been warmly accepted by the KDD community as a promising and upcoming interdisciplinary research area.

Considering our main project goals, in our call for papers we emphasized the technological aspect of the exchanges and focused on knowledge discovery from digitalized visual heritage; deep learning for image recognition in digitalized art; methods and frameworks for learning from spatio-temporal and formal aspects of art images across different cultural areas, timeframes and media; data visualization and visual analytics methods and tools for studying culture-specific artifacts (e.g. pre-modern East Asian prints); data management platforms and frameworks for collecting or constructing coherent large data sets of images of different provenance, medium, quality scattered among different collections; unification of digitalization practices across diverse public and private stakeholders; and platforms and prototype solutions for adopting deep learning in the analysis of visual and cultural artifacts.

We intended to cast a wide net and attract a diversity of scientists including experts from the fields of data mining, GIS, Art History, and East Asian Studies as well as museum curators, librarians and collectors working on different topics, issues guided by a variety of methods and intellectual concerns. In response to our call published on different platforms used by Art Historians, Data Scientists and Asian Studies Scholars and advertised through collegial networks and a website (https://dsdah2018.blogs.dsv.su.se) we received a good number of full papers and paper proposals representing many research issues, approaches, materials and cultural areas of research. After peer-review screening, where each proposal was evaluated by one Art Historian and one Data Scientists (members of the Programme Committee), we selected papers for the workshop. Unfortunately, several high-quality papers submitted by North American researchers were not presented in London due to financial restrictions (the lack of funding for intercontinental travel and the high conference registration fee). Also, the keynote speech titled "Machine Unlearning", which was to be delivered by Lev Manovich, Professor of Computer Science at the Graduate Center, City University of New York (CUNY) and Director of the Cultural Analytics Lab, had to be suddenly cancelled.

The workshop was held on Monday, August 20, 2018. It opened with the short presentation Data Science for Digital Art History: Negotiating Close and Distant Reading delivered by the two organizers, followed by two sessions and the discussion. The first Full Paper Session was reserved for three twenty-minute presentations while the second Spotlight Presentations featured six ten-minute papers. The closing discussion revolved around the challenges faced by researchers interested in developing interdisciplinary collaborations between Art History and Data Science. It concluded with the proposal of building an online platform capable of supporting our newly emerging research network. Considering the engagement and enthusiasm of the workshop participants, who presented highly interesting projects and travelled to the workshop from different academic centers in Europe, the U.S. and Japan, it can be expected that given the opportunity the network imitated at the workshop could transform into strong collaborative research partnerships with the potential to strengthen the interdisciplinary field.

The Workshop Follow-Up

From the outset of our collaboration we envisioned that the papers presented at the workshop would be published. After the workshop the papers were collected, peer-reviewed, rewritten and submitted to the International Journal for Digital Art History. However, although presented as a collection, it needs to be stressed that the papers presented at the conference cover a wide range of issues, materials and approaches

and are not guided by a unified research theme. Rather than a weakness we consider this a strength of our endeavor directly resulting from our premise and the experimental character of our research initiative. Our goal as editors was not to mold the papers into a coherent narrative that would reverberate with our own individual research agenda. We planned to showcase an open-ended approach to exploratory basic science and instead expose the nature of interdisciplinary collaborative projects between Art History and Data Science. In their paper Tracey Berg-Fulton and her colleagues stress the importance of an open-minded approach, sustained dialogue and respect for all participants regardless of their disciplinary provenance as the key to successful collaboration. Hence, regardless of our individual disciplinary origins and research interests it was crucial for us to maintain a non-hierarchical inclusive outlook on science that resulted in papers that may have different value for different disciplines.

The papers presented in this section tackle a great diversity of topics, research materials, and methodologies ranging from the GIS-based study of vernacular mapping in Japanese early modern screen painting and visual analytics of Hebrew manuscripts to the application of unsupervised computer vision methods to generate metadata from diverse art works, and the use of Formal Concept Analysis to facilitate explorative interactive viewer experiences among people viewing diverse collections of digitalized art and material culture. It is clear from these papers that deep learning techniques as well as simple data features can provide great first insights when it comes to computational art-type classification, visual analytics and interactive visualization on digital manuscripts, as well as when handling uncertainty from automated analysis of art. In these papers, we observe two main angles of applying machine learning to Digital Art History, unsupervised and supervised learning, with some explicitly focusing on one of the two, while some of them fall in between. With regard to unsupervised learning, a group of papers present exploratory data analysis and visualization approaches for image segmentation and annotation. Wijntjes focuses on perpetual aspects within pictorial art and stresses the weakness of completely automated machine learning approaches for complex problems, such as gaze direction, suggesting the need for having the 'human in the loop', and hence presenting an exploratory data analysis angle to solving this problem. In a similar context, Pateiro et al. present the challenges of analyzing manuscripts due to their inherent data complexity. A visualization environment is presented for exploratory data analysis on manuscripts with complex textual dependencies that can provide humanities experts with strong insights on understanding and structuring their data. Based on the notion of Formal Concept Analysis, Cole et al. present a data exploration approach for visualizing and getting insights from large collections of images, by employing standard context and content retrieval methods from Data Science

such as query-by-example, and concept similarity matching under the nearest neighbor framework. Yang et al. focus on supervised learning and feature extraction from massive amounts of digitized images from the Metropolitan Museum of Art, WikiArt, and Artsy, spanning several decades. They provide a data integration framework for open access image sources and apply ResNet50, a CNN architecture for image recognition for classifying images based on time period and type, achieving a promising degree of predictive performance when classifying image types while maintaining decent accuracy values when classifying images over time. Due to the inherent complexity of the problem, i.e., diversity of art movements, the achieved degrees of accuracy are significant and provide promising directions for future investigation of alternative deep learning architectures.

To recap, the vast amount of Data Science methods applied to Digital Art History target data exploration, exploratory data analysis, visual analytics, and interactive visualization emphasizing the need for keeping the user/human expert in the loop. At the same time, the necessity for handling the inherent data complexity is emphasized and standard techniques, including dimensionality reduction, formal concept analysis, and feature reduction are employed with promising results. Moreover, the use of standard deep learning architectures demonstrates, on one hand, the need for disciplinary background provided by the humanities experts, whereas on the other hand it paves the way towards the development of novel deep learning frameworks and architectures for addressing the major challenges of data complexity with respect to meaningful and useful feature extraction, as well as the exploitation of time and space. Consequently, examples of future research directions from the Data Science perspective of Digital Art History include (a) the development of new dimensionality reduction methods and feature-extraction mechanisms from complex Digital Art History data, such as digitized manuscripts and images, (b) the construction of novel neural network architectures based on CNNs and LSTMs with attention mechanisms to address the time and space variables, (c) the design of user-interactive tools with advanced machine learning and data management capabilities that can be deployed in real-time scenarios, such as museum navigation, and (d) explicitly maintaining the users and human experts to provide interactive feedback to the learning process via techniques such as reinforcement learning or active learning.

Final Reflections

The expected outcome of our research initiative was to critically reflect on the interdisciplinary collaboration between diverse research communities and its epistemological and ontological effects. It was clear that Data Science provides methodologies and insights to analyse cultural artifacts and processes on a large scale, which can facilitate paradigmatic shifts in academic interpretation and use among the wider public. At the same time, the concepts and tools developed in Art History enrich data mining, machine learning and industry applications. We expect that top-tier Data Science and machine learning publication venues will embrace this new line of research by introducing Data Science for Digital Art History as a scientific research topic, will welcome more workshops on this theme, and will even introduce short technical tutorials presenting the field from the art history viewpoint. Our intention is to promote the aforementioned types of dissemination at upcoming Data Science and machine learning conferences, such as KDD 2020, ICDM 2020, and IJCAI 2020. We also expect that once the Data Scientists embrace visual heritage as an exciting and rewarding research venue and contribute to the development of methodologies capable of analysis of culturally diverse visual data we will see the emergence of a pluralistic non-hierarchical Digital World Art History, true to its name.

Thanks to our project we also have learnt that interdisciplinarity is not necessarily limited to the synthesis between two or more disciplines. As discussed by Andrew Berry and Georgina Born, the integrative synthesis model is only one of the options available.[25] Other possibilities include subordination-service mode and agonistic-antagonistic mode, but the options are endless. Also, it needs to be emphasized that the disciplines themselves are often heterogeneous. A discipline does not always imply a fixed set of problems, objects, practices, theories or methods. Art History and Data Science are good examples of this intellectual fluidity, which cannot be mistaken for a lack of scholarly rigor. It needs to be stressed that from the outset we intended to avoid the subordination-service mode, in which one discipline has a strong sense of authority and the other is assigned a service role often conceived as making up for a lack in the "master" discipline. We consciously avoided the situation where Data Science acts as simple provider of technological solutions for Art History, or Art History is seen as an uncomplicated provider of data. This mode of partnership is often observed in interdisciplinary collaborations between the Natural and Human Sciences. Instead, we were interested in experimenting with an agonistic-antagonistic mode of interdisciplinary relations in which the disciplines clash and through this clash reveal the fundamental assumptions, otherwise invisible and unquestioned by the disciplinary insiders, by which they are structured. In the process of our collaboration we concurred that this mode of collaboration has the potential to facilitate more radical epistemic and ontological shifts in knowledge practices, which we both are interested in pursuing in the future. We would like to invite our readers to consider these issues when reading the papers presented in this section.

NOTES

1 Barry, Andrew and Georgina Born. *Interdisciplinarity: Reconfigurations of the Social and Natural Sciences*. London: Routledge 2013.

2 Provost, Foster and Tom Fawcett. *Data Science for Business*, Sebastopol: O'Reilly, 2013.

3 Bishop, Claire. "Against Digital Art History." *Humanities Futures* (2017): n.p. The article was also reprinted in vol. 3 of *The International Journal for Digital Art History* issued in 2018.

4 Bentkowska-Kafel, Anna. "Debating Digital Art History." *The International Journal for Digital Art History* 1 (2015): 51-64.

5 Jaskot, Paul. "Review of Debates in the Digital Humanities." *Visual Resources* 29, no. 1-2 (2013): 135-140.

6 Jaskot, Paul. "Review of Debates in the Digital Humanities." *Visual Resources* 29, no. 1-2 (2013): 140.

7 Jaskot, Paul. "Review of Debates in the Digital Humanities." *Visual Resources* 29, no. 1-2 (2013): 140.

8 Drucker, Johanna and Anne Helmreich, Matthew Lincoln et Francesca Rose. "Digital Art History: The American Scene." *Perspective* 2 (2015): 152-180.

9 Moretti, Franco. "The Slaughterhouse of Literature." *Modern Language Quarterly* 61, no. 1 (2000): 207-227.

10 Langfeld, Gregor. "The Canon in Art History: Concepts and Approaches." *Journal of Art Historiography* 19 (2018): 152-180.

11 Jõekalda, Kristina. "What Has Become of the New Art History?" *Journal of Art Historiography* 9 (2013): 152-180.

12 Estill, Laura. "Digital Humanities' Shakespeare Problem." *Humanities* 8, no.1 (2019): 45.

13 The projects such as "The Next Rembrandt" https://www.nextrembrandt.com can be a good example of this phenomenon.

14 Elkins, James. *Is Art History Global*, New York, London: Routledge, 2007; Zijlmans, Kitty and Wilifred Van Damme. *World Art Studies: Exploring Concepts and Approaches*, Amsterdam: Valiz, 2008; Carrier, David. A World Art History and its Objects, Philadelphia: Pennsylvania State University Press, 2008.

15 Bahrani, Zainab and Jas Elsner, Wu Hung, Rosemary Joyce, Jeremy Tanner. "Questions on 'World Art History'." Perspective: Actualite en Histoire de L'Art 2 (2014): p. 181-194.

16 Tyler, Lamar. *The Gatekeepers are Gone: Hustle + Technology = Success*. Atlanta: Tyler New Media, 2014.

17 Toressen, Jim. "A Review of Future and Ethical Perspectives of Robotics and Aim", *Frontiers in Robotics and AI* 4 (2018): 75.

18 Jasonoff, Sheila. *The Ethics of Invention Technology and the Human Future*. New York: W.W. Norton & Company, 2016; Freitas, Alex. *Comprehensible Classification Models: A Position Paper*. SIGKDD Explor. Newsl. 15, no. 1 (2014): 1-10.

19 Nguyen, Khuong and Zhiyoun Luo. "Conformal Prediction for Indoor Localisation with Fingerprinting Method." *Artificial Intelligence Applications and Innovations* 3 (2012): 214–223, 2012. Ribeiro, Marco T .and Sameer Singh, Carlos Guestrin. "Why Should I Trust You? Explaining the Predictions of Any Classifier." *KDD 2016 Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (2016): 1135-1144.

20 Bentkowska-Kafel, Anna and Hugh Denard, eds. *Paradata and Transparency in Virtual Heritage*. London, New York: Routledge, 2016.

21 Langmead, Alison and Thomas Lombardi, David Newbury, Christopher Nygren. "A Role-Based Model for Successful Collaboration in Digital Art History." *International Journal for Digital Art History* 3 (2018): 152-180.

22 Manovich, Lev. "Data Science and Digital Art History", *Journal of Digital Art History* 1 (2015): 13-35.

23 Langmead, Alison and Thomas Lombardi, David Newbury, Christopher Nygren. "A Role-Based Model for Successful Collaboration in Digital Art History." *International Journal for Digital Art History* 3 (2018): 152-180.

24 Emmeche, Claus and David Budtz Pedersen, Frederik Stjernfelt. Mapping Frontier Research in the Humanities. London, New York: Bloomsbury Academic, 2018.

25 Barry, Andrew and Georgina Born. I*nterdisciplinarity: Reconfigurations of the Social and Natural Sciences*. London: Routledge *2013*

BIBLIOGRAPHY

Bahrani, Zainab and Jas Elsner, Wu Hung, Rosemary Joyce, Jeremy Tanner. 2014. "Questions on 'World Art History'." *Perspective: Actualite en Histoire de L'Art* 2: 181-194.

Barry, Andrew and Georgina Born. 2013. *Interdisciplinarity: Reconfigurations of the Social and Natural Sciences*. London: Routledge.

Bentkowska-Kafel,Anna. 2015. "Debating Digital Art History." *The International Journal for Digital Art History* 1: 51-64.

Bentkowska-Kafel, Anna and Hugh Denard. eds. 2016. *Paradata and Transparency in Virtual Heritage*. London, New York: Routledge.

Bishop, Claire. 2017. "Against Digital Art History." *Humanities Futures*: n.p.

Carrier, David. 2008. *A World Art History and its Objects*, Philadelphia: Pennsylvania State University Press.

Drucker, Johanna and Anne Helmreich, Matthew Lincoln et Francesca Rose. 2015. "Digital Art History: The American Scene." *Perspective* 2: n.p.

Elkins, James. 2007. *Is Art History Global*, New York, London: Routledge.

Emmeche, Claus and David Budtz Pedersen, Frederik Stjernfelt. 2018. Mapping Frontier Research in the Humanities. London, New York: Bloomsbury Academic.

Estill, Laura. 2019. "Digital Humanities' Shakespeare Problem." *Humanities* 8 (1): 45.

Freitas, Alex. 2014. *Comprehensible Classification Models: A Position Paper. SIGKDD Explor. Newsl. 15 (1): 1-10.*

Jaskot, Paul. 2013. "Review of Debates in the Digital Humanities." Visual Resources 29 (1-2): 135-140.

Jasonoff, Sheila. 2016. *The Ethics of Invention Technology and the Human Future*. New York: W.W. Norton & Company.

Jõekalda, Kristina. 2013. "What Has Become of the New

Art History?" *Journal of Art Historiography* 9: n.p.

Langfeld, Gregor. 2018. "The Canon in Art History: Concepts and Approaches." *Journal of Art Historiography* 19: n.p.

Langmead, Alison and Thomas Lombardi, David Newbury, Christopher Nygren. 2018. "A Role-Based Model for Successful Collaboration in Digital Art History." *International Journal for Digital Art History* 3: 152-180.

Manovich, Lev. 2015. "Data Science and Digital Art History", *Journal of Digital Art History* 1: 13-35.

Moretti, Franco. 2000. "The Slaughterhouse of Literature." *Modern Language Quarterly* 61 (1): 207-227.

Nguyen, Khuong and Zhiyoun Luo. 2012. "Conformal Prediction for Indoor Localisation with Fingerprinting Method." *Artificial Intelligence Applications and Innovations* 3: 214–223.

Provost, Foster and Tom Fawcett. 2013. *Data Science for Business*, Sebastopol: O'Reilly.

Ribeiro, Marco T .and Sameer Singh, Carlos Guestrin. 2016. "Why Should I Trust You? Explaining the Predictions of Any Classifier." *KDD 2016 Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*: 1135-1144.

Toressen, Jim. 2018. "A Review of Future and Ethical Perspectives of Robotics and Aim", *Frontiers in Robotics and AI* 4: 75.

Tyler, Lamar. 2014. *The Gatekeepers are Gone: Hustle + Technology = Success*. Atlanta: Tyler New Media.

Zijlmans, Kitty and Wilifred Van Damme. 2008. *World Art Studies: Exploring Concepts and Approaches*, Amsterdam: Valiz.

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