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Philosophical perspectives on computational research methods in digital history

The cases of topic modeling and network analysis

This chapter has three main objectives: firstly, to discuss several philosophical positions regarding research methods; secondly, to outline certain features of scientific methods; and, thirdly, to use this terminology to look at digital history.

In a brief sketch on several historically important philosophical positions concerning research methods I first aim to show that the search for the one "correct" scientific method has recently given way to a more pluralistic conception of research practices.

Next, I outline some of the general features of scientific methods – not as a comprehensive description of research methods, but rather as an attempt to shed light on the often neglected point that methods are closely related to the academic goals we are working toward. Although these goals may be uncertain or changing, critical reflection on the connection between methods and what we are trying to achieve in our research has the potential to increase our awareness of the limitations and possibilities of certain methods.

Lastly, I use this philosophical terminology to look at digital history – a comparatively new historical subdiscipline that is distinguished by its computational methods – and discuss two different digital methods. My PhD project is concerned with the investigation of a specific methodological practice, computational modeling, on which there are still ongoing debates as to what the feasible goals for this method could be. The following methodological reflections are part of my ongoing investigations into the nature of research methods.

Acknowledgements: I would like to thank Dr. Mareike König, German Historical Institute (Paris) for her valuable feedback on an earlier draft of this paper, and the Luxembourg National Research Fund (FNR) (10929115), who funded my research.

https://doi.org/10.1515/9783110723991-006

1 Historical perspectives on research methods and philosophy

Before the establishment of independent philosophical subdisciplines associated with individual scientific disciplines, philosophical investigations into the nature of research methods often coincided with the task of explaining human reasoning. Although these investigative attempts aimed for generality, they also emphasized the need to provide concrete instructions on what the scientific method should look like. Examples of this approach toward methods are well known. René Descartes suggested that knowledge proceeds from first principles known a priori and with certainty,[1] while Francis Bacon claimed that we gain knowledge of the world by collecting observable evidence and then extend this knowledge by generalization.[2]

During the course of the twentieth century this traditional philosophical view of research methods changed dramatically. The development can most easily be summarized under the label of diversification, which describes the process from the search for the one "correct" scientific method toward a more pluralistic conception of academic research in general. In this pluralistic landscape, general approaches and specific studies of individual elements of research can be seen as complementary, rather than in conflict with each other.

In the first half of the twentieth century, general approaches to methods and objectives in the humanities were less widespread than in the sciences but still common. In contrast to the philosophical discussion about natural science, which focused on the logical relationship between theories and evidence, the debate in the humanities focused on the question of how the human dimension of the research object requires a specific method and thus distinguishes natural science from the humanities.[3] Participants in these discussions emphasized that the study of human experiences depends on a specific form of understanding conceived as a distinct kind of hermeneutic practice, which is not adaptable to the natural sciences.

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1 René Descartes, "Rules for the Direction of the Natural Intelligence," in *Descartes: Selected Philosophical Writings*, ed. John Cottingham, Robert Stoothoff, and Dugald Murdoch (Cambridge: Cambridge University Press, [1701] 1999), 1–19.

2 Francis Bacon, *The New Organon*, ed. Lisa Jardine and Michael Silverthorne (Cambridge: Cambridge University Press, [1620] 2000), 33.

3 See for example Wilhelm Dilthey, *Introduction to the Human Sciences*, ed. Rudolf Makkreel and Frithjof Rodi, Selected Works I (Princeton: Princeton University Press, 1989); or Max Weber, "Objectivity in Social Science and Social Policy," in *The Methodology of Social Sciences*, ed. Henry Finch and Edward Shils (New York: Free Press, 1949), 50–112.

It is sometimes assumed that in the humanities the systematic discussion of methods is less widespread than in the sciences. That this is not the case can be seen by the recent work of Rens Bod.[4] In his innovative account of the historical development of the humanities, he carefully outlined the importance of methodological principles within the humanities.[5]

The philosophy of science has also moved away from the grandiose old philosophical systems toward more specific questions concerning scientific work, such as, What should be considered as evidence and how can it be related to theories?[6] A general and still fairly influential proposal in this regard was the hypothetico-deductive approach of Carl Hempel.[7] Put in simple terms, this approach considered the scientific method as consisting in the suggestion of a hypothesis, the derivation of consequences from this hypothesis, and the testing of whether those consequences can be observed. For Hempel, this approach provided a general procedure to get us closer to the conceived goal of science, i.e. the formulation of laws of nature.

Although philosophical accounts of research methods such as the hypothetico-deductive approach provide useful insights into the logic of research, it is clear that this kind of philosophical theorizing started with an already comparatively abstract picture of the objects of research and how they should be investigated. These accounts rarely reached the level of the working researcher and the more mundane problems of their work. The second half of the twentieth century saw considerably more attention being paid to the local circumstances of knowledge production. The watershed moment in this process toward more attention being paid to local research practices was the publication and reception of Thomas Kuhn's monograph *The Structure of Scientific Revolutions*.

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4 Rens Bod, *A New History of the Humanities: The Search for Principles and Patterns from Antiquity to the Present* (Oxford: Oxford University Press, 2013), 364.

5 For a general examination of the role methods play in the sciences see Robert Nola and Howard Sankey, *Theories of Scientific Method: An Introduction* (Stocksfield: Acumen, 2007); Hugh Gauch, *Scientific Method in Brief* (New York: Cambridge University Press, 2012). For an overview of the role that methods play in the humanities and history see Simon Gunn and Lucy Faire, eds., *Research Methods for History* (Edinburgh: Edinburgh University Press, 2012); and James E Dobson, *Critical Digital Humanities: The Search for a Methodology* (Urbana: University of Illinois Press, 2019).

6 In this context, the discussion revolved around deductive, inductive, and abductive reasoning. See Nancy Cartwright, Stathis Psillos, and Hasok Chang, "Theories of Scientific Method: Models for the Physico-Mathematical Sciences," in *The Cambridge History of Science: The Modern Physical and Mathematical Sciences*, ed. Mary Jo Nye, 5 (Cambridge: Cambridge University Press, 2003), 21–35.

7 Carl G. Hempel, "Studies in the Logic of Confirmation," *Mind* 54, no. 213 (1945): 1–26.

According to the Kuhnian picture of science, methods are embedded in historically changing paradigms.[8] Kuhn questioned traditional distinctions between normative and descriptive approaches toward research methods and argued that the rules for their application and evaluation depend on the larger context of a paradigm. Philosophers like Paul Feyerabend further undermined the distinction between normative and descriptive approaches toward research methods by claiming that there are no genuine normative methodological principles at all.[9] In the aftermath of the Kuhnian revolution, the study of science took a variety of different forms, ranging from historical studies focusing on the epistemological principles behind methods and the sociological context of research,[10] to a more general practice-oriented approach.[11] These approaches found that research methods can have a wide variety of context-dependent functions, mirroring the heterogeneity of the different disciplines themselves.

After several decades of intense intellectual exchanges neither the older, more general, approaches nor the newer contextual approaches toward scientific research methods have prevailed. Currently, the status quo in the philosophy of science is characterized by the comparatively peaceful coexistence of the different approaches. In Section 2 I outline one central feature of research methods – their goal-directedness – which is especially important to understanding how such methods can be evaluated.

2 Methods and goals

Methods, in the sciences as well as the humanities, are means to attain the goals of individual disciplines such as history, biology, or physics. "Means" here primarily designate a set of activities a researcher can engage in. These activities range from what goes on in one's mind while doing research (reasoning, thinking, imagining, inferring) to actions that involve interaction with our

8 Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 4th ed. (Chicago: The University of Chicago Press, 2012), 8.
9 Paul Feyerabend, *Against Method*, 3rd ed. (London: Verso, 1993), 14.
10 See Bruno Latour and Steve Woolgar, *Laboratory Life: the Construction of Scientific Facts* (Princeton: Princeton University Press, 1979), 21–42; or Andrew Pickering, *Constructing Quarks: A Sociological History of Particle Physics* (Chicago: University of Chicago Press, 1984), x.
11 See Ian Hacking, *The Taming of Chance* (Cambridge: Cambridge University Press, 1990), 1–10; as well as Philip Kitcher, *In Mendel's Mirror: Philosophical Reflections on Biology* (Oxford: Oxford University Press, 2003), xi.

environment (observing, measuring, gathering data, reading, conducting interviews, writing, collecting specimens, performing experiments).

Methods provide a focal point for a discipline's self-identity. Traditionally, students are introduced to a research field by learning to master the most important methods of that field. This process leads the novice from the laborious study of procedures, principles, and rules, to full immersion in a discipline. Students thus acquire the ability to apply these methods, without assistance, in order to answer new research questions. Research questions often include the formulation of certain goals and in most cases also specify the methods to be used to reach those goals.

In practice, it is often the case that the proposed goals and methods of a research project change over time, in an iterative process, but this does not impair the close relation between methods and goals.

The goals of methods can encompass general objectives such as knowledge, prediction, control, explanation, and understanding, as well as domain-specific, lower-level objectives such as the accurate description of a historical event, the explanation of a physical phenomenon, the classification of biological species, or the collection of evidence. It is important to notice that when we talk about methods being goal-directed we use an ellipsis to express the fact that methods used by researchers are used to achieve certain goals. Therefore, it is not a method in itself that achieves a goal but the researcher implementing the method who achieves the goal.

Usually, it is assumed that the achievement of these goals is not the result of arbitrary luck, but rather the outcome of the systematic work of a community of researchers who think about and critically evaluate their methods. This already reveals one central point about methods. The evaluation of a method depends crucially on the goals we have. A method is not intrinsically good, bad, or adequate but is good, bad, or adequate in relation to a specified goal the method is directed toward, as well as in relation to the goals of the discipline. Goals in this sense are determined by individual researchers and the scientific community. Sometimes higher-level goals and lower-level goals conflict with each other or are not coordinated appropriately to further the progress of a discipline. A lower-level objective can be perceived as undesirable by some researchers because they are not aware of how it contributes to higher-level goals. On the other hand, it is also possible to criticize a method when it is not clear how the method contributes to the overall goals of the discipline.

A method can be said to be adequate if it helps us to achieve a certain objective. Wendy Parker defined adequacy to achieve a purpose, with the help of a tool, in the following way:

> ADEQUACYC: A tool M is ADEQUATEC-FOR-P if and only if, in C-type instances of use of M, purpose P is very likely to be achieved.[12]

We can reformulate this conception of adequacy for methods in general as:

> ADEQUACYM: A method M is ADEQUATEM-FOR-G if and only if, in C-type instances of use of M, goal G is very likely to be achieved.

The notion of ADEQUACYM helps us describe methods as a reliable way to reach a certain goal. In this sense, methods are fallible and depend on the presence of the right circumstantial factors. C-type instances designate the context in which a method is used. The method to measure temperature, for example, consists of the use of a thermometer in a certain unobstructed context. In this case, the goal is the representation of temperature. The establishment of the adequacy of a method is possible through one of two ways. Either the method has been successful in the past or we understand the underlying processes of the method well enough to be confident in its efficiency before actually testing it.

It is not always easy to say what the objectives of a method are. The objective cannot be a specific result. It rather has to be something like a range of possible outcomes informing us about the object under investigation. What I mean by a range of possible outcomes is that a tool, like a thermometer, or a procedure, like the measurement of temperature, is not used to depict a single temperature point but rather represents the temperature of the object it is applied to at the time of the measurement.

Consider a situation described by the historian and philosopher of science Hasok Chang.[13] In the early days of the history of thermometers, scientists had no way to judge the correctness of those instruments, except by comparing them with each other. It proved especially difficult to establish fixed temperature points (which in turn were needed to create quantitative scales), like the boiling point of water, in situations where there were no independent methods of temperature measurement available. This problem was particularly hard to solve because it was not known if certain physical phenomena, such as the boiling point of water, appear at a fixed temperature point at all. The problem persists even if we account for the exclusion of distorting factors like impurities in the water, atmospheric pressure, and so on. Here, the aim of the instrument – to measure temperature – was itself such an obscure notion that it was difficult

12 Wendy S. Parker, "Model Evaluation: An Adequacy-for-Purpose View," *Philosophy of Science* 87, no. 3 (2020): 461.

13 Hasok Chang, *Inventing Temperature: Measurement and Scientific Progress*, Oxford Studies in Philosophy of Science (Oxford: Oxford University Press, 2007), 57–102.

to assess the reliability of the methods used. In the end, a variety of different measurement methods (one of which was the experienced body temperature) were used to correct each other. This turned out to be useful for studying the phenomenon, as well as for improving the methods over time.

In general, research methods can assume two different roles.[14] The distinction between these roles shares similarities with the distinction between the *context of discovery* and the *context of justification* in the philosophy of science. In the first role, methods can encompass activities that have an auxiliary function in the research process.

Procedures used to acquire funding, determine how to get to conferences, or decide how to organize teaching activities are practical research-related activities. Such methods, although important to the research enterprise and probably systematic, do not play a role in the way in which we justify our knowledge claims, and they therefore belong to the context of discovery. This context also includes sources of inspiration outside the realm of rational justification, such as dreams, spiritual inspirations, and subjective preferences. In their second role, methods can also support the results of research in an epistemic manner. An example here is the use of comparative script analysis to date an inscription. In this case, the procedure we use to determine the date of a manuscript – i.e. the comparison of different texts – provides a reason for us to believe that the inscription has a certain age, and thus belongs to the context of justification. Faulty procedures undermine knowledge claims if, for example, the corpus of texts is incomplete. Proper procedures, in contrast, strengthen knowledge claims. In the following, I will be primarily concerned with methods in this narrower, epistemic sense. Since the second half of the twentieth century, the distinction between the context of discovery and the context of justification has been a point of contention. There is a sense that, even in the discovery process, epistemic considerations play a role – while, in actual research, what is claimed to be done or believed for epistemic reasons is sometimes influenced or distorted by external factors: non-epistemic factors. For conceptual clarification, it is nonetheless useful to distinguish between these two roles that methods play, even if the distinction cannot always be sharply drawn.[15] In history, the epistemic function of methods is generally accepted. In this respect Jörn Rüsen writes:

14 Nola and Sankey, *Theories of Scientific Method*, 18–9.
15 This distinction was originally popularized by Hans Reichenbach. For a more recent discussion see Jutta Schickore and Friedrich Steinle, *Revisiting Discovery and Justification: Historical and Philosophical Perspectives on the Context Distinction* (Dordrecht: Springer, 2006), vii–xix.

> Why method? It is a matter of acquiring historical knowledge from the empirical facts that are left from the past and thereby, in general, accessible in the present (so to speak, in front of your eyes). The methodological procedures of this acquisition serve to strengthen this knowledge and to systematically justify its plausibility or validity. Methods make knowledge justifiable by verifiability of its statements.[16] (Translation my own.)

The application of methods also distinguishes research as a systematic enterprise. Doing research is having a plan – it embodies some kind of order, and is not arbitrary. Even when this order is intentionally given up, as in the case of exploratory or speculative research, it should be clearly distinguished from method-based research. This systematic approach also contributes to the progress of academic research, given that the progress of a discipline does not only depend on what we know but also on how we get to know it.

Establishing adequate goals for methods is in itself a sophisticated part of scientific research. With new areas of research especially, it usually takes time to figure out how certain methods can be used. One such comparatively new research field is the focus of the next section.

3 Digital history

In some instances, methods are influential enough to create scientific disciplines and subdisciplines around them. Digital history – a subdomain of history – is a case in point, but what is it about? In the following I present two proposals for defining the field.

We can define digital history in a first approximation as the historical subdiscipline concerned with the use of digital methods to study the past.[17] Digital methods used in digital history are dependent on computers and their various capacities, such as the performance of computations and the processing and storage of data. This definition presents digital history as an area characterized by the application of certain computational/digital techniques. It is not unusual to describe a historical subdiscipline in this way. Oral history, for example, is characterized by its focus on the acquisition and use of certain sources and not by a specific topic.[18]

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16 Jörn Rüsen, *Historik: Theorie der Geschichtswissenschaft* (Cologne: Böhlau Verlag, 2013), 55.

17 For a recent review of the state of the digital history subdomain see Annemieke Romein et al., "State of the Field: Digital History," *History* 105, no. 365 (2020): 291–312.

18 Donald A. Ritchie, *Doing Oral History*, 3rd ed., Oxford Oral History Series (New York: Oxford University Press, 2015), xiv.

Unfortunately, this simple definition has the drawback that it is too broad to be very useful. It would make every historian a digital historian because the use of computers has permeated the academic landscape more or less completely. To characterize the whole of academic history as digital history would run counter to our desire to delineate an area within history in which the use of computational techniques has taken on a special role distinct from the everyday uses of those techniques.[19]

If we are interested in getting a better understanding of digital history on a theoretical level we have to further specify how the computer is used by digital historians. My second definition characterizes digital history not only by its use of computers but by the fact that this work could not be done without computers. In this sense, the digital historian is a historian whose work would not be possible without the help of a computer.[20] This also means that the computer plays a special role in the justification of the claims in this area. The definition could therefore be rephrased as: digital history is the historical subdiscipline in which a certain kind of knowledge of the computer as a tool to justify historical claims is indispensable. This definition has the advantage of capturing our intuitive feeling that not every use of the computer has the same importance for the outcome of our research. Using digitized pictures of historical events can be important, but our knowledge of the computer we use plays a comparatively minor role in the claims we make with the help of those pictures. But if we use a database to store and query a large number of pictures or other data, knowledge of how the query works is indispensable for the reliable use of the technique.[21]

Working with large amounts of data, and the sophisticated representation and visualization of these data with the help of automated algorithms, fall within this second definition. Given the comparatively recent origin of the field of digital history, this list of methods is not fixed – neither is it foreseeable which methods will be permanently established within history.[22] But there are,

19 I assume that the establishment of specialized online platforms like https://ranke2.uni.lu/ and https://programminghistorian.org/ for teaching the application of the computer as a research tool, along with the establishment of specialized journals and research centers, is a manifestation of the process in which the computer has taken on this role.

20 Here, "would not be possible without the help of a computer," should be interpreted more in practical terms: it is of course imaginable in theory that, given enough time and resources, humans could perform the tasks of computers, but it is clear that this is not possible in practice.

21 This does not mean that everything about a tool has to be known in order to use it, but rather that, for certain uses, some sort of basic understanding is necessary.

22 Romein et al., "State of the Field," 310.

nonetheless, clear examples of the application of digital methods extending the horizons of traditional historical research.

I should also add another clarification. Digital history, although it involves the use of a computer, is not limited to computational methods. This is important because, in most cases, we see that computational methods are embedded in a web of other research activities. In Section 2, I argued that methods are directed toward certain goals. What about the goals of digital history? This question can only be answered by looking at specific methods. I will therefore look at two well-established methods in this area: topic modeling and social network analysis. At first sight, it may seem that digital history, because it is defined through its methods rather than through its goals, is directed toward the traditional goals of history. I also mentioned in Section 2 that different methods can be used to achieve the same goals – therefore a change in methods does not necessarily imply a change in goals. But changed methods certainly create the possibility for the consideration of new goals. We see this clearly with my first example of a computational method – topic modeling.

3.1 Topic modeling

The computational study of text corpora was one of the first applications in the humanities to use the calculating power of modern computing machines.[23] Nowadays, machine learning techniques such as topic modeling have become an attractive method for studying large amounts of textual data. Because of the highly structured way in which text is available, it is comparatively easy to transfer text documents into machine-readable form, thereby making the processing of large amounts of text possible.[24] The early use of computational text analysis coincided with the traditional role of text as the primary form of evidence in the humanities. The reading of a text provides humans with information that goes beyond the perception of markings on a page. The traditional way of describing this feature of language is that words and sentences have semantic meaning. A sentence can provide information about the intentions, beliefs, and desires of an author, and can constitute evidence if we are interested in exploring those things. A text, as the manifestation of the writing behavior of

23 Susan Hockney, "The History of Humanities Computing," in *Companion to Digital Humanities*, ed. Susan Schreibman, Ray Siemens, and John Unsworth (Oxford: Blackwell, 2004), 3–19.
24 For other text-based methods and natural language processing techniques see chapter 3 of Shohreh Haddadan, chapter 4 of Ekaterina Kamlovskaya, and chapter 6 of Eva Andersen in this volume.

an author, can also provide us with information beyond the conscious mental state of the author, allowing us to interpret the writing as the outcome of the cultural practices, social relations, and power structures of the time. Given the fundamental interest of historians in questions such as why somebody acted the way they did, or how somebody experienced something, textual evidence and methods related to textual sources have been of prime importance in historical research. In contrast to the automated processing of text, this traditional form of reading is known as close reading.

Topic modeling algorithms analyze text and calculate the probabilities for certain groups of words to co-occur.[25] The assumption here is that words that occur together share a semantic relationship. It is intuitively plausible that if the words "garden," "flower," and "earth" appear together in a text, there also exists a semantic relationship between them.

A well-known example of this is Robert K. Nelson's Mining the Dispatch project.[26] Nelson used topic modeling to mine a large number of fugitive slave advertisements from the *Daily Dispatch* newspaper of Richmond, Virginia in order to explore the changes of topic over time. A topic like military recruitment was identified by words like "service," "men," "company," "arms," "state," "companies," "Virginia," "war," and so on.[27] In this way, it was possible to discover some of the unexpected aspects of these ads, such as humor.[28] More recent applications of topic modeling have operated in a similar way and have shed new light on large-scale cultural developments in areas like the history of science, economics, and music production.[29]

Topic modeling assumes that the probability of words occurring together in a text is an expression of a semantic relationship. In practice, this is not always the case. Words may appear together by coincidence, without representing any semantic relationship. Before a text can be analyzed, words like "the," "of,"

25 David Blei, Andrew Ng, and Jordan Michael, "Latent Dirichlet Allocation," *Journal of Machine Learning Research* 3 (2003): 993–1022.

26 "Mining the Dispatch," last modified November 2020, http://dsl.richmond.edu/dispatch/pages/home.

27 "Mining the Dispatch," last modified November 2020, https://dsl.richmond.edu/dispatch/topic/32.

28 "Mining the Dispatch," last modified November 2020, https://dsl.richmond.edu/dispatch/introduction.

29 Shawn Martin, "Topic Modeling and Textual Analysis of American Scientific Journals, 1818–1922," *Current Research in Digital History* 2 (2019); Lino Wehrheim, "Economic History Goes Digital: Topic Modeling the Journal of Economic History." *Cliometrica* 13, no. 1 (2019): 83–125; and Matthias Mauch et al., "The Evolution of Popular Music: USA 1960–2010," *Royal Society Open Science* 2, no. 5 (2015): 1–10.

and "to" have to be removed because they are less significant in determining the semantic topics in a text. In cases of words with little semantic value it is necessary for the researcher to manually distinguish significant from non-significant results.[30]

Historians have for a long time been interested in large-scale developments such as the changes in public opinion in a country or the existence of certain cultural practices over long periods of time. Without quantitative methods, arguments of this scope cannot be justified, as the cognitive abilities of humans are limited.[31] In such cases, automated procedures are needed to help researchers – and topic modeling can be seen as an auxiliary tool for automatically finding certain semantic correlations in texts. But, by providing new methods, computational tools also create new goals and transform older ones. The goal of training a machine learning model on a large corpus of texts in order to detect topics did not exist in the analog era. And a formerly unfeasible goal, such as the large-scale description of more major cultural developments – which at the same time captures at least some aspects of the outcome of cultural practices like writing texts – becomes much more tractable than with traditional methods.

3.2 Social network analysis

Social network analysis quantitatively describes the connections between different entities within a network. It thereby provides the possibility of representing certain relationships according to the rules of graph theory, the mathematical subdiscipline whose rigorous framework can be used to formulate explicit definitions about the constituents of a network.[32] A graph consists of a set of vertices (nodes) with lines (edges) between those vertices. Different kinds of centrality measures can be used to describe and visualize how the nodes representing the entities in the network are related. The formal representation of the relationship between different entities within a social network makes it

30 Matthew L. Jockers and Rosamond Thalken, *Text Analysis with R: For Students of Literature*, Quantitative Methods in the Humanities and Social Sciences (Cham: Springer International Publishing, 2020), 230.

31 Paul Humphreys, *Extending Ourselves: Computational Science, Empiricism, and Scientific Method* (New York: Oxford University Press, 2004), 6.

32 For more details about social network analysis see chapter 1 of Antonio Fiscarelli in this volume. See also Garry Robins, *Doing Social Network Research: Network-based Research Design for Social Scientists* (London: Sage, 2015).

possible to use automated algorithms to explore the properties of the network or to visualize it.

The entities represented in this way do not have to be individual humans but can also include words, institutions, material things, and so on. The only important thing is that the relationship between the entities can be expressed in mathematical form. The example in Fig. 1 shows the relationship between a set of school pupils. Every circle represents a child in a school class. The data were collected by Johannes Delitsch, a pioneer of social network analysis, in the 1880s.[33] Based on his observations in class he created a table of friendship gestures, reciprocal relationships, and other measures. The nodes in this figure were ordered according to the degree of connectedness to other nodes, with the nodes with the highest degrees of connectedness shown in the middle and colored in darker blue than the rest of the nodes.[34]

Network analysis is most applicable in cases where we assume we will find significant relationships between entities. The relationships which constitute a network are not only idle ways to describe individual facts but rather can be used to explain certain effects that are dependent on the existence of a network. These effects might include the spread of information, or a disease, as well as the likelihood that certain events will take place. Traditional history often depends on narratives as a main tool to represent the past. Network analysis extends the toolbox of possible representations of the past by use of a formally rigorous theory of networks. The interpretation of what exactly is represented with the help of networks is dependent on the historian. As in the case of topic modeling, the ability to automatically create and visualize networks from large datasets allows historians to bring new details into focus. Describing centrality, for example, is an easy way to formulate hypotheses about a social actor in a network.

33 Richard Heidler et al., "Relationship Patterns in the 19th Century: The Friendship Network in a German Boys' School Class from 1880 to 1881 Revisited," *Social Networks* 37, no. 1 (2014): 1–13.

34 The original data used to create this network were compiled by the German primary school teacher Johannes Delitsch. Between 1880 and 1881, he observed the behavior of his pupils' school class. I created the picture with the Gephi graph visualization software. Data: https://github.com/gephi/gephi/wiki/Datasets. For the use of Gephi, see Bastian Mathieu, Sebastien Heymann, and Mathieu Jacomy, "Gephi: An Open Source Software for Exploring and Manipulating Networks" (Third International Conference on Weblogs and Social Media, ICWSM, San Jose, USA, 2009).

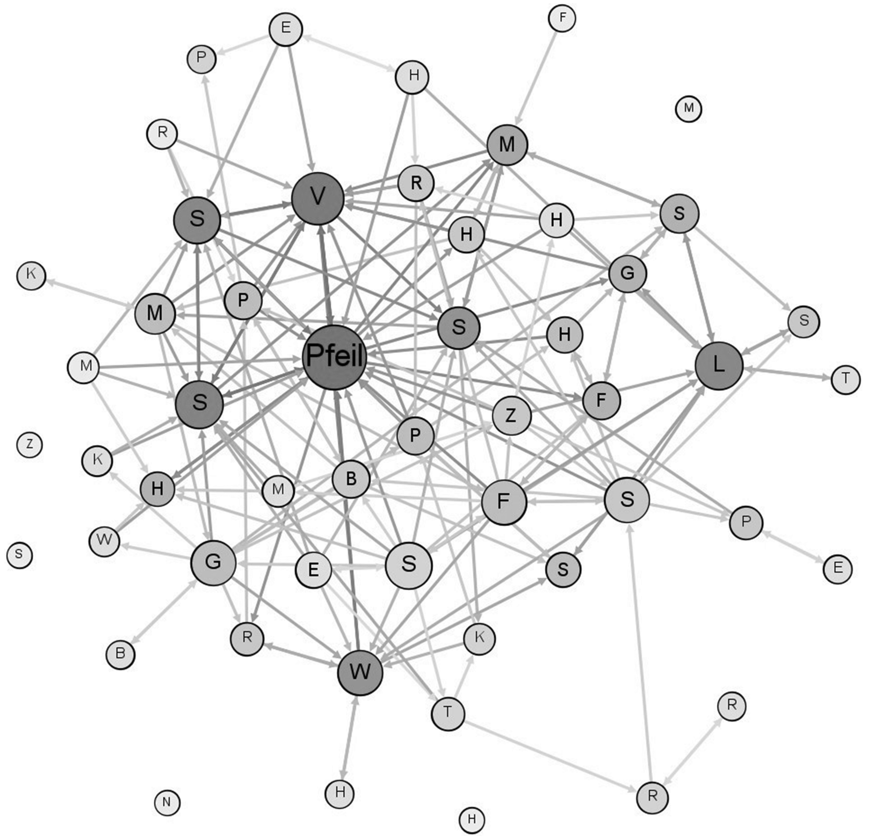

Fig. 1: Visualization of a friendship network between schoolchildren, created with Gephi. The surnames of children have, except for pupil Pfeil, been abbreviated to the first letter of their surname. The color densities indicate the number of gestures of friendship Delitsch observed; the arrows show whether the friendship was reciprocated or not reciprocated. 2019. © Thomas Durlacher.

3.3 The pitfalls of computational methods

Of course, digital (or computational) methods are not without their issues. So, what are some of these problematic features? I want to outline two such features which are especially relevant for the epistemic function of digital methods in the research process. The first concerns the plasticity of computational representations. Once data are in a machine-readable binary format it is easy to make changes to them and manipulate them. The way we visualize and represent something with the help of a computer, although it can be expressed explicitly, is also prone to being modified. This has to do with the flexibility of a computer as a universal computing machine.[35] In the examples I mentioned in Sections 3.1 and 3.2 it is easy to see that the careless interpretation of the output of computational methods could undermine the usefulness of the method. Personal biases, as well as a lack of understanding of what the computer is doing, magnify the problem.

The second problematic feature of computational methods I want to discuss here concerns *epistemic opacity*.[36] Computer programs often present themselves as black boxes where only the input and the output are accessible to the researcher. In the context of scientific research, this feature has been called epistemic opacity because the complex and autonomous structure of the programs used obscures the epistemic role that different program parts play. For non-epistemic tasks this is not problematic, because only the result, and not how it was generated, counts. In Section 2, I mentioned that methods and procedures can have an epistemic role. If it is not clear what is happening during a procedure then we do not know how it supports our claims. Therefore it is of great importance for historians to extend their critical methods and understand those parts of programs and algorithms that are relevant for their knowledge claims. In the context of digital hermeneutics, this task has been described as a continuous process that accompanies every step in the research process. Algorithm criticism, digital source criticism, tool criticism, interface criticism – all are part of a methodological reflective process aimed at ensuring the reliability of the methods we use.[37] In cases of novel techniques imported from other disciplines, this reflective process will be supported by experiments to reveal possible applications in the research process.

Plasticity, like epistemic opacity, is connected with the strengths of computational methods, automated processing, and rule-based representational techniques. In topic modeling, as with social network analysis, both of these features can undermine the results of our research. In the case of topic modeling, the machine learning algorithm searches for probabilities between words, but when we look at the results alone it is not immediately clear how they were generated. Important decisions have to be made by the researcher, the number of topics has to be chosen, and parameters configured. This makes the topic modeling method

35 Johannes Lenhard, *Calculated Surprises: A Philosophy of Computer Simulation* (New York: Oxford University Press, 2019), 10.
36 Humphreys, *Extending Ourselves*, 147.
37 Andreas Fickers, "Update für die Hermeneutik. Geschichtswissenschaft auf dem Weg zur digitalen Forensik?," *Zeithistorische Forschungen – Studies in Contemporary History* 17, no. 1 (2020): 157–68.

susceptible to being fitted toward a preferred outcome. To a certain degree, this may be true for all methods, but the novelty and lack of well-established standards is especially worrisome in the case of computational methods which have not been used in historical research before.

When it comes to social network analysis, these problems mainly appear in the ways in which networks are visualized. Automated algorithms are often used to bring networks into a visually appealing form. Here too, the way the network is presented often remains a mystery to the user. One way to counteract such problems is to reverse engineer the results and try to independently confirm that an outcome is meaningful and not just the artifact of an algorithm.[38] This requires time and resources but is of great epistemic importance with regard to the role that methods play in the research process.

4 Conclusion

Methods play a central role in academic research. Because of their importance, reflection on methods and their evaluation – from the perspective of historians as well as those collaborating with them – is critical to ensure that research is a systematic enterprise. For history, this is important for its internal, as well as its public, accountability. The evaluation of methods depends crucially on the goals those methods are directed toward, which are themselves part of an intricate web of goals and values in a discipline. A lower-level goal like the representation of a social network, or the automated detection of topics in a text corpus, does not always fit into the web of the higher-level goals of a research project or, on an even higher level, a discipline. When a research project is, for example, purely focused on individuals, it has to be argued how or whether these methods, usually aimed at the analysis of macrostructures, will contribute to the purpose of the project. Some hints of how this is possible have been given in Sections 3.1 and 3.2. Of course, the evaluation of these methods will not always result in a positive conclusion. The introduction of new methods also needs to be accompanied by discussion and reflection on the ways these methods can be integrated into and used in a discipline. Many of the chapters collected in this volume provide examples of this process and give a good account of how such developments are currently shaping digital history.

38 Juan M. Durán and Nico Formanek, "Grounds for Trust: Essential Epistemic Opacity and Computational Reliabilism," *Minds and Machines* 28, no. 4 (2018): 645–66.

In the field of history, the most recent methodological innovations in the form of computational techniques also require the critical assessment of those methods to make sure they reliably serve the epistemic aims of historians. In the case of computational methods, I have pointed out two features of these methods that could, if ignored, undermine their epistemic function: i.e. their plasticity and epistemic opacity.

Biases, lack of understanding, and unfeasible goals can be a detriment to research. This chapter can be understood as an invitation to critically compare the methods introduced by digital history with the general aims of the historical enterprise. In this regard, the cases of topic modeling and social network analysis are intended to show how computational techniques are related to the aims of history and how they can change our representations of the past.

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