Iconizing the Digital Humanities: Models and Modeling from a Semiotic Perspective

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Abstract: *»Die Ikonisierung der Digital Humanities. Modelle und Modellierung aus einer semiotischen Perspektive«.* Models are ubiquitous in the digital humanities. Against the backdrop of the recent discussion in the philosophy of science about what models are and what they do, this paper presents a semiotic perspective on models in the framework of Charles S. Peirce's theory of signs that sheds light on the practice of modeling in the digital humanities. As a first step, it is argued that models are icons, i.e. signs that represent their specific objects by being regarded as similar to them; and that there are, in all, three basic types of model, namely "images," "diagrams," and "metaphors." A second step explicates relevant implications of this model-theoretic approach, especially as they relate to the digital humanities. In particular, it is shown that models are not identical to the things they represent and that they only represent them partially; that the representation operates on the basis of a mapping relation between select properties of the model and its object; that each model and each instance of modeling has a theoretical framework; and that models are the true basis for genuine creativity and progress in research.

Keywords: Models, icons, images, diagrams, metaphors, C. S. Peirce, Digital Humanities.

1. Iconic Perspectives on Digital Humanities

Modeling is as ubiquitous in the digital humanities as it is in today's scientific research.[1] Scholars use models for creating an ever-growing number of computational tools that expand the breadth and depth of humanities research. The traditional objects of study are transferred into the digital realm by being "modeled" by computers so that computations can be done that provide new and, if possible, exact insights. Modeling in the digital humanities opens up

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[1] Models play an ever-growing role in contemporary science: see Bailer-Jones (2009) and Frigg and Hartmann (2017); cf. Thalheim and Nissen (2015a) with case studies from a diverse range of research fields. On models in the digital humanities, see McCarty (2005, 20-72), and Ciula and Marras (2016); for a general perspective, see Schreibman, Siemens and Unsworth (2004, 2016).

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new avenues of research and at the same time reshapes the way scholars do their investigations.

This computational turn, or at least digital expansion of traditional methodology, takes place all over the humanities and, to a varying degree, affects all fields of study, both in research and in teaching. In particular, this holds true for Classical Studies, an area that was among the first to embrace the digital age.[2] To give just a few examples, scholars of Greco-Roman antiquity have created digital 3D models of ancient buildings;[3] interactive mapping tools to explore ancient landscapes and travel routes;[4] network models of the axiomatic-deductive relations among proofs in ancient mathematics;[5] models of the materiality of the medieval manuscripts that contain the ancient texts;[6] models of citation networks of references to ancient texts in modern scholarly literature;[7] large-scale databanks that contain analyses of the syntactic structures ancient texts exhibit;[8] digital editions of Greek and Latin texts;[9] and corpus-

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2 For the early development of computational approaches in Classical Studies, see Solomon (1993); for a more recent account see Crane (2004). One of the first and most long-lived projects in the digital humanities is the "Thesaurus Linguae Graecae" (TLG), a databank of ancient Greek literature that began in 1972 (<http://stephanus.tlg.uci.edu>); for a history of the project see Thesaurus Linguae Graecae (2017). Another long-lived project in Classical Studies is the "Perseus Digital Library," which began in 1985 (<http://www.perseus.tufts.edu>); its core is a large-scale collection of texts and other testimonies from ancient Greco-Roman culture, including pictures of material remnants and scholarly literature. Interestingly, the systematic use of models in order to acquire objective, "scientific" knowledge seems to have been invented in ancient Greece itself; see Lattmann (2015). In any case, the first attestation of a word for model, "*parádeigma,*" belongs to an inscription in the so-called Tunnel of Eupalinos on the Greek island of Samos, which was built in the 6th century BCE; see Käppel (1999).

3 E.g., of the Athenian Acropolis: see Tsingas (2012). Cf. The Digital Institute for Archaeology's "The Million Image Database" project (<http://www.millionimage.org.uk/>).

4 Cf. the "Ancient World Mapping Center. 'À-la-carte'" project that allows the GIS-based creation of custom maps for ancient Greece and Rome on the basis of historical cartographic material (<http://awmc.unc.edu/awmc/applications/alacarte/>). For the modeling of ancient travel routes see, e.g., "ORBIS: The Stanford Geospatial Network Model of the Roman World" (<http://orbis.stanford.edu>). Cf. interaction models as described by Nakoinz (2013); see also Nakoinz and Hinz (2015).

5 Cf. Schiefsky (2007).

6 Cf. Campagnolo (2015).

7 Cf. Romanello (2016).

8 Cf. the efforts relating to building large-scale treebanks, with the goal of creating a basis for comprehensive computational linguistic analyses: see, e.g., the "Ancient Greek and Latin Dependency Treebank (AGLDT)" (<https://perseusdl.github.io/treebank_data/>) project that was started in 2016; cf. Mambrini (2016) and see Bamman and Crane (2010, 2011).

9 See the "Homer Multitext" project (<http://www.homermultitext.org/>); cf. Crane (2010) and Almas and Beaulieu (2013). Often these editions allow various analyses of the textual material; cf. the "Digital Athenaeus" project (<http://digitalathenaeus.org/>) that aims at providing the tools for analyzing text reuse and sources of quotations; for the latter, cf. Bozia (2016), Celano, Crane and Majidi (2016), and Gorman and Gorman (2016). For another

based digital lexica that use sophisticated statistical methods.[10] Despite the apparent diversity of these tools that provide new perspectives on, and methods for investigating, the traditional objects of research in Classical Studies,[11] it is clear that they are nothing but, or at their core rely upon, digital versions or "models" of those objects proper which they are meant to stand for.[12]

As essential as models are for the digital humanities, they are not mere tools that do not exert any influence on what scholars are investigating. Quite the contrary, models shape what we see to a considerable degree, and it is arguably the case that they even determine what we *can* see. For example, if we create a digital political map of ancient Greece, by investigating this model we might only find out what the borders of the Greek states were, but we cannot discern, e.g., which cultural relations existed between the single parts of Greece, beyond and independently of the political landscape; moreover, this model might be understood as implying that there actually was something in antiquity that was identical to "borders" in the modern sense. To give another example, if we model ancient travel with direct distance as the only criterion for choosing routes, we cannot see that the primary factor in making a travel decision might instead have been the travel costs in terms of time and expenses.[13]

In principle, it is not the original, "real" object that we access in the digital humanities, but a substitute, i.e. the "model," which we ourselves create, explore, investigate, and manipulate. But how exactly do digital models relate to their original objects? What are the conditions under which we may use them? What are, after all, the advantages and disadvantages, the limitations and benefits of models? In view of the ever-growing importance of digital models in the

example, see Bernstein, Gervais and Lin (2015); cf. the "Tesserae Project" (<http://tesserae.caset.buffalo.edu/>).

[10] See, e.g., Bamman and Crane (2009), in particular for their discussion of some of the differences in scope and method when compared to traditional lexica, such as the standard "Greek-English Lexicon" by Liddell et al. (1996 [1940]).

[11] Another example of how digital technologies might change traditional research and teaching is the "Perseids" Project, which is nested into the "Perseus Digital Library" and implements crowdsourcing approaches: cf. the project homepage (<http://sites.tufts.edu/perseids/>) and see Almas and Beaulieu (2016).

[12] Cf. Ciula and Marras (2016) as well as McCarty (2004) who locates "modelling" at the core of the digital humanities and contends that it "points the way to a computing that is *of as* well as *in* the humanities: a continual process of coming to know by manipulating representations." However, McCarty's position differs from the perspective taken here insofar as he sees modeling only as a heuristic tool and "essentially a quest for meaningful failure": "The best model of something, that is, comes as close as possible to what we think we know about the thing in question yet fails to duplicate perfectly that knowledge" (both quotes McCarty (2003, 1232)). For a more in-depth discussion of this position, see McCarty (2005, 20-72).

[13] See Scheidel (2014) on the rationale of the "ORBIS: The Stanford Geospatial Network Model of the Roman World" project (<http://orbis.stanford.edu>).

humanities, it is of paramount importance to be able to give sufficient answers to these questions.

Seldom though do the practitioners of the field seem to be interested in exploring such abstract and at their core philosophical issues.[14] To a certain degree, this is to be expected and, admittedly, justified, for modeling is an inherently practical activity and as such it does not necessarily require that we have a sophisticated theory of models. Moreover, there is a confusing variety of model-theoretic approaches in the scholarly literature from divergent and often incompatible perspectives.[15] In consequence, it seems to be all but impossible to adequately define and comprehensively explore the notions of "models" and "modeling," even if only in order to sharpen our methodological toolkit for practical purposes.

This situation should not be surprising. Apparently, it is caused by the specific nature of the subject matter itself. As the small number of examples of digital models in Classical Studies given above already suggests, it does not seem to make much sense to try to apply the label "model" to all the divergent things that are commonly called "model." After all, there does not seem to be "the" model, but only "models," and this only in a very loose sense; after all, it is hard to see what all these "models" could have in common. What, for example, does a digital map have in common with a treebank; or what does a bibliographical model have in common with a 3D reconstruction of an ancient temple or a robot model of a Roman gladiator? Apart from being something "digital," there does not seem to be any single characteristic property (or set of properties) that these things share with one another. The word "model" might just be a highly polysemous word so that the search for a general theory of model might be futile and, in any case, not worth the effort.

This paper disagrees. It will, first, sketch an answer as to whether there is a universal definition of model that covers all the models used in the digital humanities (and beyond) in the affirmative.[16] This model-theoretic approach operates in the semiotic framework of Charles S. Peirce's theory of signs and proposes that models are a specific form of sign, namely icons, i.e. signs that

[14] However, cf. McCarty (2005, 20-72). To be sure, the situation is similar to that in theoretical science: see Gähde and Hartmann (2013).

[15] For an overview, see Bailer-Jones (2009), Frigg and Hartmann (2017), and Frigg and Nguyen (2017); for a brief account of the history of model theory, see Morrison and Morgan (1999b). Cf. Thalheim and Nissen (2015b, 2015c) as well as Nissen and Thalheim (2015a, 2015b, 2015c).

[16] I have put forward this model-theoretic approach together with Björn Kralemann elsewhere; here I can only present the outlines of this theory and, especially in section 3, point out some ramifications for our understanding of digital humanities as a genuinely model-based field. For a fuller account, see Kralemann and Lattmann (2013a, 2013b) and cf. Lattmann (2012, 2015, 2016); cf. Gallegos (2018). Nonetheless, I will take the opportunity to more fully explicate some of the relevant implications of this approach, especially as they relate to modeling in the digital humanities.

are defined as being similar to what they represent.[17] A second step will trace relevant implications of this understanding of models that will provide insights into what we can and cannot hope, and try, to achieve by modeling and thus in digital humanities at large. This section will demonstrate that it is not only possible to give a universal definition of model, but that it might also be helpful to do so.

2. Iconizing Models

Modeling is an essential feature of using computers as a research tool, whether in science or in the humanities. In order to compute anything, one has to build and use models that resemble those things outside the computer about which the sought-for computations shall be made, whether these things are physical objects or theoretical concepts or whatever else.[18] The inherent reliance of computing on models is readily apparent at the higher levels of computing, for example in object-oriented programming languages, for they are based on the idea of modeling software objects that are, due to some sort of similarity, regarded as equivalent to things existing in the "real" world, here those things scholars are interested in investigating in the first place, such as the original Greek and Latin texts themselves.[19]

It directly follows that digital models are categorically different from their original objects and, in principle, not identical to them. Rather, they stand for

[17] There are certain similarities to other approaches that understand models as signs in the framework of Peircean semiotics; cf., e.g., Ljungberg (2016). Among the main differences, though, are the following two points: here, the notions of model and icon are strictly identified; and second, other model-theoretic approaches are integrated into the overarching semiotic framework. These are, first, the model-theoretic approach of modern logic (see, e.g., Balzer (1997); cf. Hodges (2013); for an account of its earlier development, see Chang (1974) and Vaught (1974)); and second, those model-theoretic approaches that describe models from the viewpoint of the concept of mapping (see, e.g., Stachowiak (1973); cf. Giere (1999, 2004), Suárez (2003, 2004), Frigg (2006)).

[18] For clarity's sake and to avoid misunderstandings, it is important to stress that the notion of "reality" shall be understood in a broad sense as implying that something has the capacity of actually affecting and/or acting upon another thing. In the terms of Peirce's theory, this amounts to something's being a phenomenon of "secondness." The intricate question, though, as to what "'reality" exactly meant for Peirce has been controversially discussed; for some insights see Mayorga (2007) and cf. below.

[19] This is the case even at the most basic level of computing, for the electric states of computers represent, and stand for, those numbers (etc.) that make up the relevant (abstract or specific) data structures (etc.). That computers have a basically semantic (or semiotic) nature is evident in view of the general characteristics of the Turing machine, as which each computer can be described, for the two core components of the Turing machine, "program" and "data," are conceived of as categorically separate, with the "data" by definition having a "symbolic" (and that is semiotic) nature; cf. Barker-Plummer (2016).

and "represent" these objects as their ontologically separate substitute in the digital realm.[20] Insofar as representations are nothing but signs and signs can be investigated via semiotics, the general theory of signs, we have to take a semiotic perspective and explore models as signs. For this aim the sign theory developed by the American philosopher Charles S. Peirce is well-suited, especially because it is embedded in a comprehensive and powerful epistemological framework.[21]

What then is a sign? Peirce defines it as "something which stands to somebody for something in some respect or capacity" (Peirce CP 2.228), that is, a sign is conceived of as something that is an element of a relational structure that is established by an intentional action, that is, by someone's *using* something as a sign. Anything can (and does) act as a "sign" if and insofar as, for some person (or, more generally, entity that is capable of establishing a sign relation, including computers) it represents some "object" and, to continue quoting Peirce's definition, "creates in the mind of that person an equivalent sign, or perhaps a more developed sign," the so-called "interpretant" (Peirce CP 2.228).[22]

[20] For clarity's sake, I should stress that a representation does not necessarily need to be (whatever that means) "realistic" or "naturalistic," e.g., as one might conceive of a photography. If something represents another thing, this just means that, in someone's judgment, the one thing stands for the other thing. Evidently, this can be the case even if there is no resemblance at all, such as when we use the demonstrative pronoun "this" in order to deictically point to something. On the other hand, neither a representational nor a similarity relation implies that one of the relata must be a simplified version of the other; for this widespread view see, e.g., McCarty (2004). In effect, models can be as complex as their original objects and maybe even more complex; for example, an exact replica of a human being could be classified as a model, even if under most circumstances it probably might not be a very useful one for research purposes.

[21] This is not meant to imply that there are no other sign theories. Quite the contrary. However, taking Peirce's theory as the basis for formulating a model-theoretic approach is justified by the fact that it is sufficiently well-suited for describing models as representational (and thus) semiotic phenomena; and that it allows us to neatly integrate other model-theoretic approaches. For an overview of sign theories, see, e.g., Copley (2001); for more detailed insights into Peirce's theory of signs, see Short (2007), Atkin (2013), and cf. Colapietro and Olshewsky (1996).

[22] Cf. the full quotation at Peirce CP 2.228: a sign "addresses somebody, that is, creates in the mind of that person an equivalent sign, or perhaps a more developed sign. That sign which it creates I call the *interpretant* of the first sign. The sign stands for something, its *object*. It stands for that object, not in all respects, but in reference to a sort of idea, which I have sometimes called the *ground* of the representamen." Cf. Peirce CP 1.564: "A representation is that character of a thing by virtue of which, for the production of a certain mental effect, it may stand in place of another thing. The thing having this character I term a *representamen,* the mental effect, or thought, its *interpretant,* the thing for which it stands, its *object*." Cf. Peirce MS 318 (1907) where Peirce defines the object as the antecedent to the sign and the interpretant as the subsequent to it: "The object is what the sign finds; the meaning [or Interpretant] is what the sign leaves."

It directly follows that the things used as signs as well as their objects are, on the one hand, not confined to physical objects (i.e., *qua* physical object). Among other things, we can use words such as “unicorn” to let them stand for non-physical, abstract concepts and imagined things like a unicorn.[23] On the other hand, the notion of sign is not confined to “linguistic” signs either as they are commonly understood. For example, a wind rose can, by pointing somewhere, “stand for” and “represent” the actual direction of the wind at a given moment in time. By definition, anything can be a sign if and insofar as it is used to “stand for” and thus “represent” something else. Something being a sign is no inherent property of any specific thing, but belongs to, and is due to, the realm of semiotic practice.

In sum, Peirce’s definition of sign provides a broad conceptual understanding of signs. They are not bound to any specific form of manifestation or medium. Not only words, but also images, sounds, feelings and so on can be used as and, thus, be signs. The definition of sign in particular applies to all those things that are commonly classified as models, among them smaller or larger replicas of things, mathematical formulas, computer simulations, and digital visualizations.[24]

Given the general definition of sign, though, it is obvious that models cannot be signs *simpliciter.* While it is clear that every model is a sign, there evidently are signs that are not models. For example, the word “word” is, when used as such, a sign, but it is not a model for anything, at least not for its meaning proper, “word.” It follows that we have to determine whether there is any specific and clearly-defined sub-form of sign that can be called “model.”

At first sight, this does not seem to be the case, given the vast variety of things that are called “models.” This impression, however, is mistaken, for actually, there *is* one type of sign that can be identified with models, namely “icons.” Icons are one of the classes of sign resulting from Peirce’s exhaustive classification of all signs into the three classes of “icons,” “indices,” and “symbols” by way of differentiating the specific quality of the relation between the sign and its object.[25]

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[23] Of course, distinguishing degrees (or modes) of reality prompts quite intricate philosophical questions. As mentioned above, “reality” shall here just be taken to mean that, loosely speaking, something has an actual effect on something else; for this to be the case it does not matter what the specific mode of being of these things is. Cf. Peirce MS 339 (note of April 3, 1906).

[24] It should be stressed that all direct relata of the sign relation are signs; cf. Peirce CP 2.303 and see Peirce MS 318 (1907) and MS 339 (note of October 23, 1906). Signification, therefore, has a genuinely semiotic nature; cf. Peirce CP 1.339. A consequence is that we have to distinguish between different types of objects (two) and interpretants (three), explicating which aspect of Peirce’s theory would lead too far here; for some details, see Jappy (2016).

[25] As according to Peirce CP 2.243, the basic criterion for this classification is whether “the relation of the sign to its object consists in the sign’s having some character in itself, or in some existential relation to that object, or in its relation to an interpretant.” It would lead

Let us briefly review these three types of sign in order to understand the specific characteristics of icons and, thus, models: first, a "symbol" represents its object by standing for it because of convention or habitualization. Examples are regular words, for they represent their objects because they are commonly used in order that they represent them. The word "word" stands for a "word" only because it has been made to do so at some point in time and people have continued using the word in that way ever since. Second, an "index" represents its object by standing for it because of an actual connection to it. A wind rose, for example, is an index that represents the direction of the wind at a specific moment in time, if and insofar as it is at this given moment in time actually affected by the wind. Third and finally, an "icon" represents its object by being regarded as possessing a similarity or resemblance to its object. It is defined as "a Representamen whose Representative Quality is a Firstness of it as a First. That is, a quality that it has *qua* thing renders it fit to be a representamen. Thus, anything is fit to be a *Substitute* for anything that it is like" (Peirce CP 2.276).[26] An example is a photograph, because it represents its object *qua* being supposed to be perceptually similar to what it shows and is therefore deemed fit for serving as a substitute for it.

Insofar as this classification of all signs into icons, indices, and symbols is exhaustive, it is not only the case that models must be classified as icons, but also that they have to be *identified* with them, that is, as long as we grant that they are "signs" at all.[27] But signs they are, because, evidently, insofar as models are "models," they are supposed to stand for or represent "something," that is, semiotically, an object. Furthermore, the relation between this object and the model must necessarily be conceived of as a similarity relation, because a model, first, does not have the primary purpose of showing that something exists or exerts an actual influence, as an "index" does; nor does the relation between model and object primarily exist because of an arbitrary or habitual connection between these things, as is the case with "symbols."[28] Rather models are supposed to directly "show" what they stand for and, accordingly, we

too far to explicate the intricate details relating to this classification; for some insights, see Peirce CP 2.247-249 and 4.447-448 and cf. Peirce CP 1.369. There are different (though not incompatible, but complementary) classifications of all signs according to different criteria; for a thorough and insightful discussion see Jappy (2016, 2017).

[26] This definition is based on Peirce's theory of categories; see, e.g., Peirce CP 1.417; 1.300-353; 1.545-567; and 7.327-332; as well as Peirce L 104 (1904). For the conceptual role of Peirce's three fundamental categories for the definition of sign, see Peirce CP 2.242.

[27] This is one of the main differences to approaches to understanding models from a semiotic perspective that have been put forward. Cf., e.g., Ljungberg (2016) who equates models with "diagrammatical models" exclusively (on this form of model, see below).

[28] That an icon (model) is defined as having a similarity relation to its object does not imply that the similarity relation itself is sufficient for letting something be an icon (model), *pace* Frigg and Nguyen (2017, ch. 4). It has been denied that models are necessarily similar to their objects, e.g., by Suárez (2003); on this position, however, see Poznic (2016).

want to "inspect" them in order to gain acquaintance with, and knowledge about, what they represent as well as use them as a more accessible "substitute" for their objects that mediates between theory and "reality."[29]

In effect, models are icons, and icons are models. We can further refine this insight by availing of Peirce's, once again exhaustive, classification of all icons into three separate classes (Peirce CP 2.277).[30] The criterion for this classification is the specific type (or "quality") of similarity that is involved in the iconic sign relation. There are exactly three types: in principle, a similarity can either relate to simple ("monadic") qualities, that is qualities as such, such as the quality an object has with regard to its color; or, second, to qualities that are expressible in the form of two-term (dyadic) relations, that is relations that have, according to Peirce, an "existential" or "real" nature and are supposed to actually belong to something; or, third, to qualities consisting of three terms, which are, according to Peirce, nothing but "semiotic" qualities, that is, qualities that involve a "sign" relation. Evidently, this differentiation is based on the minimal number of relata involved in describing the respective qualities, in accordance with Peirce's relation-based notion of category:[31] monadic qualities are what they are in and of themselves ("firstness"); dyadic qualities are what they are due to some form of pairwise or, in another word, direct interaction ("secondness"); and, finally, triadic qualities are what they are due to involving something that connects two other things ("thirdness"). The single relata of these relations, however, do not have to have a simple constitution themselves. For example, also a composite variegated pattern of different colors can be classified as monadic quality insofar as each partial color is what it is due to itself and not because it stands in a specific direct relation to any other color of the pattern.

The resulting types of icon/model are "images," "diagrams," and "metaphors":[32]

1) "Images" represent their objects by representing simple qualities of their objects by way of exhibiting equivalent simple qualities of their own. This could be, for example, photographs, toy models, or our perceptual content in general. "Images" therefore are not confined to *visual* images, despite their name. There are also audible images, tactile images, audible-tactile-visual images and so on; there is no restriction as to the medium (or media) in which these icons manifest themselves. "Images" as de-

[29] On models as mediators, see the essays collected in Morrison and Morgan (1999a), especially Morrison and Morgan (1999c); see also Blättler (2015).

[30] For a detailed explication of this classification, which Peirce only gives at this place in a notoriously dense and obscure formulation, see Lattmann (2012).

[31] On the notion of quality in general, see Peirce CP 1.422-6.

[32] See Ciula and Eide (2017) for an application of this classification to models in the digital humanities.

fined by Peirce, therefore, need not be image-like in the common sense at all.[33]

2) "Diagrams" represent their objects by representing dyadic qualities of their objects by way of exhibiting equivalent dyadic qualities of their own, that is qualities that can be described by way of direct or pairwise relations. Examples are mathematical diagrams as we find them in Euclid's *Elements,* for their representational quality is the sum of all the mathematical relations among its elements, but each of these elements has a specific direct relation to any other element of the diagram that can be expressed independently of the relations to all the other elements. For example, in a diagram that features a circle that is bisected by a diameter, the diameter has a specific direct relation to the circumference for which the specific direct relation of the circumference to, say, the center of the circle is of no relevance.[34]
3) "Metaphors" represent their objects by representing triadic, that is semiotic, qualities of their objects by way of exhibiting equivalent semiotic qualities of their own. An example is the metaphor "Achilles is a lion," in the framework of which sentence the sign "lion" is assigned an uncommon representational quality for what the name Achilles habitually stands for.[35] Insofar as metaphors necessarily involve another icon and thus model, they can be regarded as meta-models that allow us to experiment with the consequences of using something as a model for another thing, here of using the (image) icon implied by the symbol "lion" for representing Achilles.[36]

Of these three types of model, it is mainly diagrammatical models that are relevant in scientific and digital humanities research. In these contexts, models are often used to represent, show, and bring to light qualities that are supposed to be essential relational properties of their objects that belong to their "real" constitution. Accordingly, diagrammatical models are supposed to lay open the objective nature of things and, at the same, time make it accessible to direct perception.

[33] It is a pervasive feature of Peirce's terminology that he often uses traditional names for objects that he redefines in a most abstract sense, but for which the things denoted by the terms as commonly understood can serve as an example. As is obvious in the case of "images," this method can lead to severe misunderstandings, for it seems to be implied that this type of sign is restricted to only visual images. This impression, however, would be mistaken.

[34] See Lattmann (2018) for a model-theoretic analysis of those diagrams that were used in ancient mathematics and especially Euclid's *Elements*. Peirce's theory of the diagram has been subject to lively discussion in recent times, especially in semiotic studies; see, e.g., Stjernfelt (2007), Queiroz and Stjernfelt (2011), and Krämer and Ljungberg (2016).

[35] For an explication of Peirce's metaphor theory, see Lattmann (2012).

[36] Cf. Ciula and Eide (2017, i35).

However, as is the case with "images," the class of "diagrams" is not restricted to visual or even mathematical diagrams.[37] The notion of "diagram" includes any icon that is meant to exhibit dyadic relations. In particular, this also applies to mathematical formulas and most computer simulations, for they, too, directly represent and exhibit (and not only express or describe) quantitative direct relations that are relevant for what the respective things are supposed to be in "reality" (see Peirce CP 2.282 and 4.530). As such signs they are nothing but icons, even if they are composed of, and formulated by way of, "symbols," namely the mathematical symbols as defined by the theory of mathematics. Accordingly, a map can still be regarded as an icon, and especially a diagrammatical model, if it also includes the non-iconic conventional names of the places depicted on it graphically. In short, any representation acts as a "diagrammatical model" that is used to iconically make accessible some sort of (static or dynamic) "structure" (or "pattern") that a thing is supposed to have or show, irrespective of which semiotic nature its constituent parts have.[38]

Evidently, "diagrams" as defined by Peirce play a central role in research. However, the two other classes of model are important, too. On the one hand, "images" can, among other things, convey a (so-to-speak) first-hand impression of the objects of study, for example, small replicas or reconstructions of ancient buildings, such as digital 3D models. On the other hand, metaphors allow us to create new concepts and explore hitherto unknown areas, in particular by transferring ideas from one area to another by semiotically equating them on the basis of postulating that they are similar, in whatever way it may be. For example, the methods developed in Classical philology by Karl Lachmann and others for creating stemmata of texts for editorial purposes were fruitfully put to use in the middle of the twentieth century in a biological context for describing evolutionary processes in the then new field of genetics.[39] Given this, metaphors are one of the most fundamental bases of human creativity, and they play an important role in modeling, too, especially as heuristic tools in the context of exploring new fields of research.[40]

[37] This is a most important point for understanding Peirce's theory of diagrams. Cf., e.g., Bechtel (2017) and Abrahamsen and Bechtel (2015) who, despite demonstrating the importance of diagrams for scientific research, presuppose that the notion of diagram is confined to (loosely speaking) visual diagrammatical (in the traditional sense) drawings.

[38] The equivalence (or at least, similarity) of the notions of "structure" and "pattern" in this regard might be particularly interesting from the perspective of the history of the humanities, which can be aptly described as a history of pattern-seeking: see Bod (2013a); cf. briefly Bod (2013b).

[39] For this example, see Bod (2015).

[40] This can already be observed at the beginning of Western science in ancient Greece: see Lattmann (2015, 2016).

3. Modeling Icons

In the final section of this paper, I want to point out some of the implications that follow from the understanding of models I have sketched in the previous section. In so doing, I hope to contribute to shedding light on the practical dimension of modeling, in particular in the field of digital humanities. In short, the train of thought is the following: (1) Models are not the things themselves; (2) from which it follows that models do not represent their objects completely, but in a complex way; (3) that is, in modeling we establish a mapping relation between the properties of the model and its object, which mapping relation depends upon a specific theoretical framework; (4) because of which models are not theories; (5) but nonetheless they are, due to the similarity to their objects, the only basis of genuine creativity and, therefore, progress in research.

(1) Models are non-identical to what they are a model of; they are not the things themselves. For example, a computer-generated 3D model of the Parthenon is not the Parthenon itself; a social network model of the Athenian elite of the 5th century BCE is not the historical social network itself; and a map of the ancient world is not the ancient world itself. At first sight, this seems to be a trivial point to make, but actually this is not so. We all too often forget that we are just investigating the model and not the original thing itself. The reason for this misapprehension is obvious: one of the fundamental presuppositions of modeling is that the model is similar to its object and therefore a well-suited substitute for it. But as similar as the model might be to its "real" object, it will in principle never be anything but a substitute.

This fact has far-reaching consequences, in particular with regard to the validity of the results that can be achieved by modeling: all the knowledge models can provide primarily and in principle relates only to the models themselves and not to their objects, that is, those things we are interested in investigating in the first place. Accordingly, models cannot provide *per se* true insights into these objects. Instead they provide only *potentially* true insights, which always have to be vetted and validated. The general way of doing so consists of, after having completed an abductive step by creating the model itself, a deductive step by which we explore what must be true if the results given by the model were true indeed; and an inductive step by which we check these implications against "reality" (amounting to some sort of "experiment"), that is, of course, as far as this is necessary and possible at all. This process might lead to a better model, if need be by iterating it until the model is judged to be sufficiently good enough.[41] Of course, especially in historical studies, one of the main

[41] According to Peirce, this is the general method of acquiring knowledge: Peirce CP 2.773-8; 2.641-4. Cf. Liatsi (2006) on the application of this method in historical and especially Clas-

problems and challenges consists in implementing the last, inductive step, given the scarcity of data as well as the fact that we can only use historical sources and are not able to do any direct experiments.[42]

(2) This leads to the second point. Because models are not the original objects themselves, but independent things of their own right that are intentionally used as "models" by treating them as similar to, and thus a substitute for, the original objects,[43] models do stand for, and represent, their objects, but in principle they do not do so completely. Instead they stand for their objects, as every sign by definition does, with respect to only select properties. For example, a treebank that consists of, and represents, sets of syntactical dependencies as they manifest themselves in ancient Greek sentences does, on the one hand, contain representations of the sentences themselves, but these representations only relate to their syntactical structure, and this without even taking into account their combination in texts beyond the single sentence. In view of this, it is in principle mandatory to always be clear about what a model is supposed to represent; in the case of treebanks, this would only be the syntactical dependencies the single sentences exhibit, not the sentences in their complete complexity or their comprehensive meaning in their pragmatic context etc.[44]

Furthermore, the fact that models represent their objects only with regard to select properties is not only a matter of including and excluding some of the properties in the model; in the process of modeling a more complex process takes place. For example, a political map of the ancient world and its semiotic object do not share the property of size; furthermore, the map displays properties that the original object does not possess, such as lines denoting borders; and it lacks properties that the original object does possess, such as the different heights of the terrain. Models, therefore, are not merely simplified, abstract versions of their original objects. Modeling often involves a sophisticated transformation of properties between original thing and model. Of course, this can have non-intended, non-trivial consequences, beyond just, e.g., looking for a line on the ground at the border of the "real" city of Athens. For example, in

sical Studies. For computer simulations of this epistemological model, see Pauwels and Bod (2013).

42 The same problem exists in several other fields of study and in particular in many areas of science: for example, an "experiment" is as impossible in astrophysics as it is in historical studies.

43 See Ciula and Marras (2016) on the pragmatic dimension of modeling in the digital humanities.

44 Of course, this does not exclude the possibility that the single sentences contain information that points beyond the sentences themselves and could be fruitfully analyzed by sophisticated methods to yield insights into relevant properties of the whole text; cf., e.g., van Cranenburgh and Bod (2017). The integrative combination of the tools and methods of current digital humanities research with the traditional hermeneutical toolbox might be the future goal of the development of the humanities at large; Bod (2013b) aptly calls this "Humanities 3.0."

treebanks there is no way to adequately represent syntactical ambiguities; instead, one has to make a clear-cut decision as to which syntactical function each element in a sentence has. This approach, however, fails at places where the ambiguity is an integral part of the meaning of the sentences, such as in those jokes or riddles whose very being a joke or a riddle essentially depends on the *actual* ambiguity of their syntactical structure.

(3) Using something as a model requires that one choose properties of the original that are to be represented by the model. How then does one choose these properties? In principle, this choice is arbitrary and subjective. As per the general definition of sign, it always depends upon that person (or entity) for whom (or which) something serves as a model. For example, someone may choose to regard a freehand drawing of some lines as a map of ancient Greece, even if no one else agreed; or one person might prefer to have the map represent political borders while another one might prefer to have it represent roadways. However, as arbitrary and subjective as this choice in principle is, it is always guided by, and takes place within, a theoretical framework, most broadly construed.

According to this framework, first, those attributes are selected that the model is thought to possess ("model attributes"); second, those attributes are selected that the model as a sign is thought to exhibit as the representation of its original ("syntactical attributes"); and, finally, a specific mapping relation is established that maps these two sets of attributes onto each other. This mapping relation (implicitly or explicitly) defines what the iconic similarity actually is that is thought to exist between the model and the original. Accordingly, the iconic similarity between the model and its object is only postulated by using something as a model, and, in effect, the judgment on how exactly the model and its object are similar is arbitrary and subjective, too, and does not depend on any "objective" similarity between them.

The theoretical framework within which the modeling process takes place need not be a full-fledged "theory," e.g., a sophisticated linguistic theory in the case of treebank analyses. Rather, any "theoretical" perspective, most broadly construed, can serve as a framework, even if only the (set of) notions provided by the natural language. As a rule, there is no necessity to choose any one *specific* theoretical framework; for example, we may decide to draw a map in accordance with what the natural language implies are features of a "map," or we can decide to draw a map according to strictly technical cartographic standards. Either map, however, will be a "map" and as such a model; and in any case, what each specific "map" means and what its semantic content is will be determined by the theoretical framework within which the mapping relation is established.

The choice of the theoretical framework all but determines the results we can achieve by using a specific model. For example, in treebanks we can use different grammatical frameworks for describing the syntactical dependencies in a sentence and each choice provides us with a different set of options for classification.[45] In effect, the explicit and implicit theoretical frameworks we have to use in modeling not only enable the building and use of models, but at the same time also determine their meaning and heuristic value. An important consequence in the digital humanities is that the basic setup of computers and the theoretical presuppositions of computer science become (implicit or explicit) presuppositions of digital models, too. For example, since we do not use analog computers and no infinite-precision real numbers can be used, in computer simulations of physical processes the parameter of time is in effect conceived of as being not continuous, but discrete, with all the obvious ramifications as to the precision and validity of the results, especially in non-linear contexts.

(4) Though models always have a theoretical framework, they are neither "theories" nor "descriptions," even if, of course, theories can imply and descriptions can describe (and thus effectively establish) models.[46] This is implied by the fundamental definition of models as icons, which rules out that they are truth-apt signs, since icons are (so-called) "rhemes" which are in principle non-truth-apt. Theories, on the other hand, are to be classified as complex truth-apt "symbolic" signs, namely (so-called) "arguments" or at least "dicisigns."[47]

It directly follows that what models stand for, and therefore a part of their "meaning," is not determined by the constitution of the thing acting as the model itself, because the relation between sign and object is by definition nei-

[45] To give an instructive example from Classical Studies, the "Ancient Greek Dependency Treebank" (<https://perseusdl.github.io/treebank_data/>) uses an annotation scheme that is based on Smyth (1956); see Celano (2016). However, this grammar is, with regard to the syntactical phenomena that are covered, less suitable from a scholarly perspective than, e.g., both Kühner and Gerth (1898-1904) whose classificatory scheme is arguably more detailed, complete, and adequate (cf., e.g., the description of conditional sentences) and Schwyzer (1988/1990) who describes the phenomena from a linguistically more up-to-date perspective. Even if, as Celano (2016) holds, the syntactical categories provided by Smyth's grammar (1956) might be relatively easy to implement, it is evident that the choice of this grammar will not in a few cases lead to non-trivial differences in the results of the syntactical analyses, with obvious consequences for the outcome of any further statistical analyses.

[46] For the latter, an instructive example is Euclid's *Elements,* one of the first and for the history of science most important and influential exemplars of systematic mathematical modeling; see Lattmann (2018); cf. Asper (2007) on the general characteristic of this treatise and its cultural-historical context at large.

[47] The details of the threefold classification of all signs into rhemes, dicisigns, and arguments are not relevant here; see Peirce CP 2.250-253. This classification is independent of, and orthogonal to, the one into icons, indices, and symbols, for it does not relate to the relation between sign and object, but to the relation between sign and interpretant: see Peirce CP 2.243. On propositions ("dicisigns"/"dicent signs") see Peirce CP 2.309-388 and Stjernfelt (2015). An icon is by definition a rheme (see Peirce CP 2.250 and 2.255) and in particular not a dicisign (see Peirce CP 2.314). An obvious implication of the fact that theories are arguments (or dicisigns) is that theories are (composite and complex) semiotic representations and therefore signs, too.

ther independently fixed by an actually existing relation between these two things nor habitualized as in the case of "indices" and "symbols," respectively.[48] Technically, the object of the model is what the object of the model *could* be, for models are signs of potentiality.[49] In consequence, all our interpretations (and "uses") of models, insofar as they are applied to anything beyond the model itself (its object etc.), are not pre-determined by the model itself; transparent examples are obscure metaphors. However, the theoretical framework of a model often acts as a counteracting force that guides our interpretations of the model. For example, whereas the natural language in most cases allows a large number of different and competing interpretations of a mathematical diagram, our theoretical understanding of mathematical diagrams suggests a more or less rigid and technical interpretation of any mathematical diagram, at least with regard to those aspects that are deemed relevant from the viewpoint of mathematics. Nonetheless, this lack of interpretative freedom is probably a sign of rather mature theories, whereas especially in new fields of research we might expect to witness a heuristic use of models that, by applying the general method of acquiring knowledge as described above, successively reduces the vast number of possible interpretations of the models in question. Especially in such a context, the use of models can be regarded as a substitute for experimentation, especially in the (digital) humanities.[50]

(5) This finally leads to recognizing what, arguably, the greatest benefit of modeling is. Even if models cannot exhibit any reason for why they might be adequate or not, what they *can* do is, as some form of embodied knowledge that can be directly inspected and investigated, mediate between theory and "real" thing, and this by iconically displaying and showing those properties of the original thing that would otherwise not be perceivable at all, even if only in

[48] It is worth stressing that models in principle have a "meaning." As Ciula and Marras (2016) remark, it directly follows that models are not only tools, but also genuine objects of study for the humanities. This also relates to the models that are used in scientific research.

[49] Cf. Peirce CP 2.247: "An *Icon* is a sign which refers to the Object that it denotes merely by virtue of characters of its own, and which it possesses, just the same, whether any such Object actually exists or not." On the connection between the notions of monadic quality and potentiality see Peirce CP 1.422-426. Describing models as signs of potentiality is preferable to regarding them as something similar to (literary) fiction: see, e.g., Frigg (2010a, 2010b). In effect, this invalidates the criticism raised against the similarity view of models; cf. Frigg and Nguyen (2017, ch. 4). Another point worth noting is that Peirce's definition of icon implies that the widespread use of the term "ontology" in computer science in the context of modeling is misleading, all the more so as it ignores the fact that any model relation is dependent on the pragmatic use of something as a model, with the consequence that any similarity between model and object depends on the judgment of the model user; cf. Ciula and Marras (2016).

[50] Cf. Stjernfelt (2011), especially on the usefulness of diagrams for experimentation. This is one of the reasons why Peirce developed the theory of "existential graphs"; cf. Peirce MS 514 (1909) and, recently, Sowa (2000) who took up that theory for a comprehensive theory of knowledge representation from a contemporary perspective.

the mode of potentiality and in the framework of a theory that guides our explications of the model. Given this, models can count as the most basic, if not only, source of genuine creativity. This is made clear by Peirce himself when he states the following regarding the usefulness of icons (and thus models) in general: "[A] great distinguishing property of the icon is that by the direct observation of it other truths concerning its object can be discovered than those which suffice to determine its construction. […] Given a conventional or other general sign of an object, to deduce any other truth than that which it explicitly signifies, it is necessary, in all cases, to replace that sign by an icon" (Peirce CP 2.279).[51] Though simple or complex "symbols," such as definitions, propositions, descriptions and theories, can represent and convey analytic knowledge and "truth" proper, only models can lead to *genuinely* novel insights. Models, therefore, form the fundamental and indispensable basis for progress in scientific as well as in digital humanities research.

4. Discussion

Gunnar Olsson's Questions

Gunnar Olsson addressed the importance of translation for being a human. He describes the human being as a genuinely semiotic animal whose life consists of translating signs between the areas of the arts, science, and religion. To each of these areas, he assigns one of the three fundamental types of sign according to Charles S. Peirce, namely icons to the arts, indices to science, and symbols to religion. In so doing, Gunnar Olsson locates the activity of translation at the core of the human condition, for we are doing nothing but constantly exchanging signs for other signs in a never-ending interplay of identity and difference.

My answers

I find Gunnar Olsson's perspective engaging and stimulating, especially from the viewpoint of model theory. If we understand models as icons on the lines of my position statement, it is just and only modeling, conceived of as thinking in the mode of iconicity, that provides us with, and actually *is*, the very source of the contents of human thought. Models are the first starting-points of each and every enquiry, and they are genuinely situated in the realm of creativity, that is the arts, most broadly construed. As such, these iconic signs are subsequently transformed by the activity of "translation," not only into other models, but also into scientific "knowledge" and/or religious "belief." But, as Gunnar Olsson's position implies, the relevance of modeling does not stop there. The secondary indexical and symbolic signs do not serve as the final products of the semiotic

[51] See Ciula and Eide (2017) on the creative aspects involved in modeling in the digital humanities.

activity of human beings, but they can be, and actually *are*, used to create new signs in turn, in particular in the mode of iconicity. These new models provide us with further, ideally more advanced, starting-points of scientific and/or religious enquiry. In effect, models not only are the ultimate source of human thought and creativity, but, insofar as we cannot escape our being humans and thus living beings in space and time, they are, in principle, also informed and shaped by our previous states of mind; that is, in short, by who and what we are. Modeling, therefore, turns out to be an integral as well as indispensable part of what it means to be a human being indeed.

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