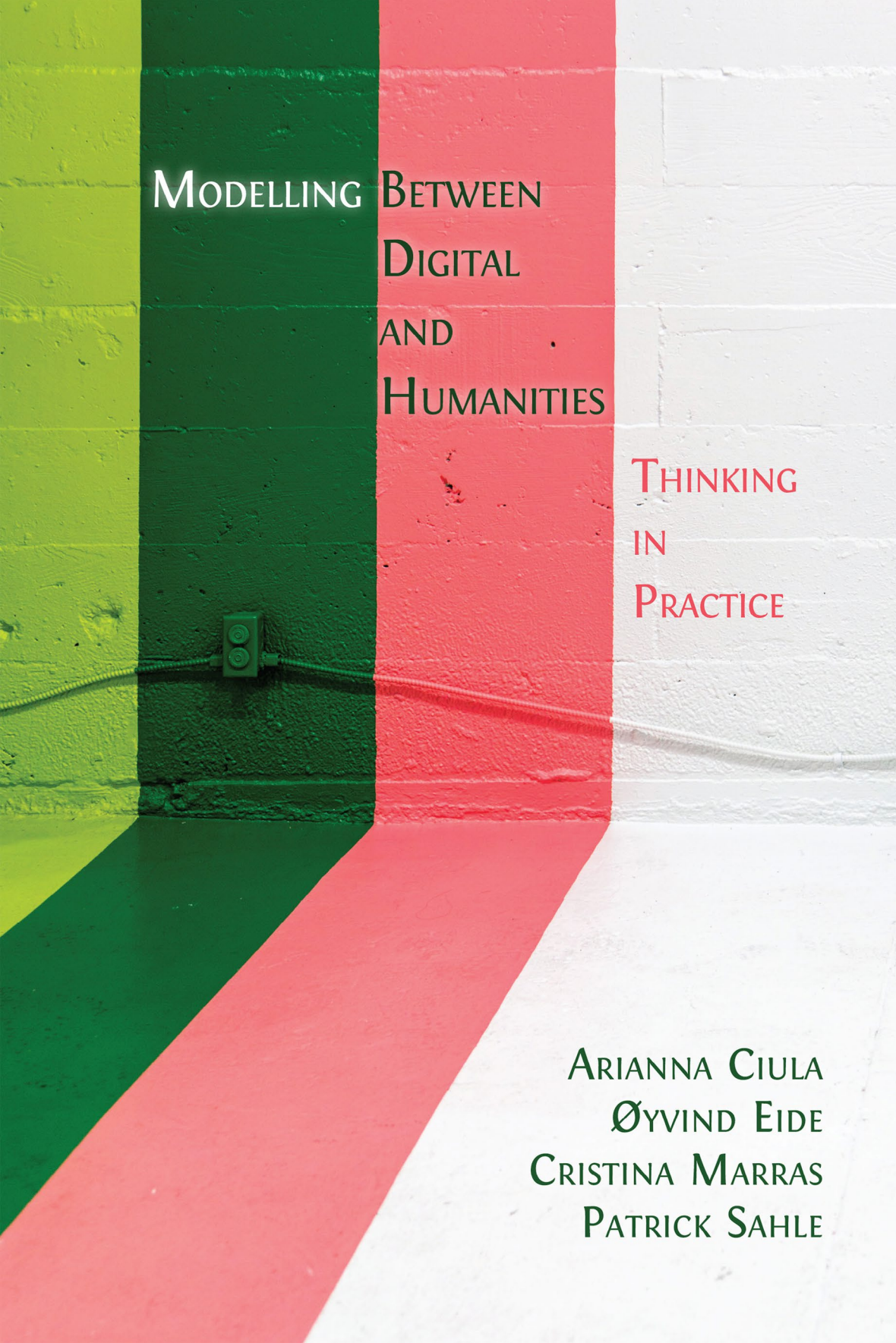
Modelling Between Digital and Humanities

Thinking in Practice



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4. Modelling as Media Transformations

4.1 Models Are Media Products

Models are created and used in modelling activities to express selected aspects of their targets in a specific and usually formalised way. In so far as they are concrete, shareable expressions, what Godfrey-Smith (2009) calls "imaginary *concreta*", they are expressed in some medium. As discussed in Chapters 2 and 3, the concept of translation could be considered the 'engine' of the modelling process, in the sense that the process of signification that unfolds in modelling activities implies translation, negotiation, and transformation of meaning. The process of signification was explained and exemplified in Chapter 3. In this chapter, the mediality of models will be discussed; as Gelfert pointed out, this is central to what we can learn from them:

> If it is indeed the case that specific encounters with models always require some concrete format or representation—be it a set of diagrams scribbled on a piece of paper, or an elaborate three-dimensional model that mimics the 'look and feel' of a target system—what we can learn from a model will fundamentally depend on how we encounter the world through it or in it. (Gelfert 2016, pp. 21–22)

We will base the discussion on the terminology proposed by Lars Elleström (2010; 2014; 2019b) to describe mediated expressions and media transformations. His approach to the study of media does not depart from the concept of media itself, but rather from the building blocks of mediated expressions, that is, from modes and modalities. It gives us a clear language with which to talk about media—a highly useful approach for us. His attempts to base the discussion on a more general understanding of media than 'text' and 'reading' fits well into the complexities of models. Indeed, what is often called

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'reading,' including of non-textual media products, is by Elleström replaced with 'perception' (Elleström 2018, p. 282, cf. p. 277) to give prominence to the sensory input and its fast interpretative connections.[105] The following three concepts are fundamental to this chapter:

- A media product has a material form and is defined by the processes in which it can be involved—it is necessary for communication to take place. It "enables the complex transfer of cognitive import from one (or several) producer's mind(s) to one (or several) perceiver's mind(s)" (Elleström 2019b, p. 22).[106] The media product has some sort of materiality, but its form does not have to be solid. Some media products may be interactive, evolving partly from or fully based on signals from the perceiver. One and the same mind can be both co-producer and perceiver of a media product. Examples of media products include a public reading of a poem, a drawing of a ship, an essay, a mathematical formula, a comforting smile directed at a nervous presenter, and an art performance.
- A technical medium is "the entity that mediates; it is the material presence that is actually perceived" (Elleström 2014, p. 49). Thus, it is what is used for the actual distribution of a media product. Technical media such as a television screen or a whiteboard can be used for many different expressions but also put limitations on the form of what can be expressed.[107]
- Qualified media denote "media categories – artistic and non-artistic – that are historically and communicatively

105 Perception is, like reading, strongly connected to meaning-making. "[A]n act of perception 'between' the media product and the perceiver's mind" is always initiated by the perceiver's sense organs and always, to some extent, followed by and entangled with interpretation. [...] Thus, compared to the potentially extensive act of production, the act of perception is brief and very quickly channelled into interpretation, which of course occurs in the perceiver's mind. Nevertheless, the type, quality, and form of sensory input provided by the media product, and actually taken in by the perceiver's sense organs, are absolutely crucial for the interpretation formed by the perceiver's mind." (Elleström 2018, p. 283).

106 See further elaborations in Elleström (2018; 2019b).

107 In agreement with the long tradition of media studies (see, e.g., McLuhan 2001) and as shown for modelling in Eide (2014), the technical medium also influences the content of what is said.

> situated, indicating that their properties differ depending on parameters such as time, culture, aesthetic preferences and available technologies" (ibid, p. 19). They include well-known media and genres such as music, painting, and news articles.[108] "A qualified medium is constituted by a cluster of individual media products" (ibid.).

Shareable models are media products. Important parts of the nature and usefulness of models can be fruitfully explored through an approach based on media studies. Our aim in this chapter is to show how this approach can clarify certain aspects of models and modelling, complementary to other approaches used in this book. In order for a model to be shareable it has to be expressed through a medium. This shareable form has a certain configuration, which can be received and understood as meaningful by those involved in modelling acts. Study of these media configurations contributes to a more holistic understanding of modelling in Digital Humanities (DH).

There is no guarantee that the intention of the model is understood by all receivers, or even that a transfer of intention is possible at all in a strict sense. But as explained in Chapter 1, modelling is a pragmatic act in which a model is created by someone with a specific purpose. An intention, in principle and to some extent, is understandable for users of the model, provided that they have the necessary competence and share enough of the cultural background with the creators of the model. This includes speaking the same language in a broad sense and is connected to the concept of 'modelling literacy'.

A popular and well-used model changes over time, both through flexible interaction, as when parts of a stage model used to prepare a theatre performance are being moved, and through permanent modifications, as when new parts are added to the stage model. Studying the model as a media product enables us to understand both processes and products of modelling as creative interactive acts used as a basis for new knowledge—new in the sense of being new for at least some of the participants in the communicative act of sharing models.

In this chapter we will discuss media modalities and how they influence modelling processes in general, and then illustrate the

108 According to Elleström, genres are submedia (2019b, p. 117).

mediality of models and the analysis of their modalities through a number of examples. We will then proceed to show how the modelling activities can be seen as media transformations.

4.2 Media Modalities

Media modalities[109] is a set of analytical categories which can be used to understand media products better. In Chapter 3 we saw how describing the material realisation of a model (its size, production process, language of expressions, materials, context of use) is useful for observing its factuality and practical affordances. Thus, the focus in this chapter is on the factuality of models, although the entanglement with the fictional aspects (see Chapter 3) will also be important to bear in mind. The four modalities defined in Elleström (2010) give us a language with which to talk about media.[110] Thus the intended use of these categories is explorative rather than prescriptive. All four modalities apply to all media products and there is no assumed development in time from the first modality to the last, either for production or for reception of media products. They are parts of a complex intertwined process of signification. All media products of all types include all four modalities. Each modality has a number of possible modes, that is, a way to be or to do things. For each media product these modes are configured in a specific way for each modality. The level of similarity between these mode configurations for two media products is a criterion for deciding whether they belong to the same qualified and/or technical medium or not.

A media product has a (1) *material* interface which meets the (2) *senses* of the recipient in a (3) *spatiotemporally*-based interpretation leading to a (4) *semiotic* understanding of the meaning of the media product in the specific case under study. The first three modalities are pre-semiotic, in that they lay down the material basis for the meaning-making, which takes place in the semiotically-based understanding of a media product.

109 This summary is based on Elleström (2010) and Eide (2015).

110 Note that Elleström explicitly uses the word 'model' in his subtitle: "A Model for Understanding Intermedial Relations".

1. *The material modality* is "[t]he latent corporeal interface of the medium; where the senses meet the material impact" (Elleström 2010, p. 36). This modality is the potential for media interaction held by all objects, in all forms and formats. It is not the physical substance of the medium, but rather the potential which is in need of something to be expressed, that which is capable of being manifested through it.

   Important modes via which material modality manifests itself include:

   a. Human bodies. Examples include bodies dancing or performing in theatre plays.

   b. Other demarcated materiality. Examples include statues, books, and TV sets.

   c. Not demarcated materiality. Examples include sound and smell.

2. *The sensorial modality* is "[t]he physical and mental acts of perceiving the interface of the medium through the sense faculties" (ibid.). Some sense-data from objects, phenomena, and occurrences meet the receptors in our cells to create sensations, that is, some sort of experienced effect. *The central modes* of this modality are the five senses: seeing, hearing, feeling, tasting, and smelling. In addition to what directly meets the senses, the sensorial modality also includes complex sensory connections, where stimulation of one sense triggers experiences in other senses.

3. *The spatiotemporal modality* is: "[t]he structuring of the sensorial perception of the material interface into experiences and conceptions of space and time" (ibid.). This modality qualifies the connection between the sensorial interaction with material media expressions and the meaning-making in the mind of the receiver. Thus, it is a complex and many-faceted modality. The focus on space and time stems from all media products being in some sense spatial and temporal. The spatiality of a media product varies greatly, from a free jazz jam or a firework show to a handwritten manuscript or a computer game. In

> modelling, it is interesting to study how and to what extent the media product changes, and what steers the changes in form. We will come back to this point later, for instance, in the difference between a drawing of a ship and a VR (Virtual Reality) system for the interaction with digital versions of paper puppets.

Space and time can both be manifested in the material interfaces of media products. Examples of space include document pages and dancing bodies, examples of time include the sound of audiobooks and dancing bodies. Time can be more or less fixed, as we saw in Section 3.3.2 with the letter-form model example. In any encounter with media expressions, there is always a cognitive space and a perceptual time. These are structurally similar but quite different from one another as the cognitive space is a space of expression and the perceptual time is the time of experiencing the media product. Virtual space and time can be experienced at a more abstract level than the space and time of the material interface. Examples include a room and the human bodies moving around in it, as they are expressed in a novel. The page of the book or the reading device is the space manifested in the material interface, while the room described in the novel is the virtual space. Creating a model of places in novels, for instance by putting them on a map, is based on the virtual space, not on the space manifested in the material interface. In models based on visual media this can be different.

The spatiotemporal modality involves a transformative process from the materiality of the media product as it is met by our senses in time, to an understanding of the possible (and often intended) space and time of the mediated expression. When played out in narrative, this modality is a complex area strongly linked to the chronotope,[111] where the direct space and time as we experience it through sensorial impressions based on the material interface mix with virtual time and space to create experiences and understanding. The spatiotemporality of the model has an important role in creating the iconographic relationship to the target, as pointed out in Section 3.4.1.

The central modes of this modality are thus:

111 Bakhtin (1981). See Eide (2015, pp. 195–198) for a discussion related to modelling and media modalities.

a. space manifested in the material interface
b. cognitive space (always present)
c. virtual space
d. time manifested in the material interface
e. perceptual time (always present)
f. virtual time

4. *The semiotic modality* is intertwined with and necessary for the other three modalities; it epitomises the meaning-seeking activities of humans as semiotic animals. It is "[t]he creation of meaning in the spatiotemporally conceived medium by way of different sorts of thinking and sign interpretation" (ibid.). The semiotic modality enables sign-grounded meaning which is based on the distinction between symbol, icon, and index that we know from Peirce's semiotics.

   The three main modes are

   a. convention (symbolic signs)
   b. resemblance (iconic signs)
   c. contiguity (indexical signs)

The first three modalities (material, sensorial and spatiotemporal) are pre-semiotic and give the material basis for the meaning that emerges in the semiotic modality. The spatiotemporal modality is essential for enabling meaning-making based on the materiality of the media product that meets our senses, whereas the semiotic modality is where the arrangement of signs happens in the process of understanding the media product. An expression will include all four modalities in a form which is specific for that expression, but still classifiable according to general rules. The modes of each of the modalities may or may not be active and are mixed in various combinations. Finding out how the modes mix in the various modalities for a media product can tell us something about the medium to which the product under study belongs. Doing this more generally for classes of media products is one strategy for better understanding the ontology of qualified media. Following up on the discussion in Chapter 3, an important focus for us is to better understand how applying this classification system to modelling

also has an epistemological bearing. In the following section we will outline how this understanding of media can be applied to models and modelling.

Elleström does not dwell on different kinds of signs and we will not systematically distinguish between types of symbolic or indexical signs. However, as discussed in Chapter 3, it is the iconic dimension of models in particular that enables reasoning in an interpretative context (such as the use of models in DH research and teaching). The same distinction across image-like, structural, and metaphorical icons outlined in Chapter 3 is therefore recalled here.

4.3 The Modelling Function

In previous works, including Ciula and Eide (2016), specific areas of model-based research have been explored in order to develop an epistemology of modelling in DH based on analyses of concrete modelling activities. In Chapter 5 of this volume, we illustrate a number of modelling examples taken from the humanities. Many are focused on the modelling of various phenomena of text as a target object, but in order to illustrate how media modalities work, it is also important to extend the diversity of the modalities beyond text.

We assume all models to be media products, used in modelling activities. In a modelling activity one or more modellers (human beings using various tools)[112] use a media product (the model) as a means to: a) understand the targets of the modelling better (model of), and b) create new modelling targets (model for). All modelling includes both a and b, but often focuses more on one than the other.[113] Thus, modelling can be seen as a combination of three elements:

$$\text{modelling} = (\text{modeller+}, \text{model}\ (\text{mediaProduct+}), \text{target+})$$

The triadic structure of this definition is in line with Minsky (1965, p. 1).[114] In semiotic terms, the targets align with the object, the

112 The role of agency in modelling and the possibility for non-human agent driven modelling was discussed in Section 3.4.2.

113 See Section 3.2 on the model of/model for distinction).

114 The definition of a model in Metasystem Transition Theory, http://pespmc1.vub.ac.be/MODEL.html, includes the relationship between the target (the modelled

media products with the representamen, and the modellers with the interpreter. Modelling is an activity in the creation of models as well as in their use. As pointed out in Chapter 3, what makes the model a sign is the interpretative act of a subject, whether in the role of creator, reader, or user. Modelling is the signification function which defines the relationships in the sign triple. A media product is a model when it takes part in a modelling activity and is perceived as a model. Thus, no object is in itself—disconnected from its use—a model.[115] The targets of modelling processes in DH can feature different levels of complexity. They can include single objects of art or literature as well as large historical and cultural frameworks or concepts such as 'feudalism' or 'text,' cf. the examples in Chapter 5.

Modelling is a pragmatic activity, encompassing the modeller, the tools used, and associated creative processes of selection. Combined approaches from semiotics (see also Chapter 3) and media studies are useful to account for the materiality of modelling and understand both its epistemological and operational aspects. Trying to decide which medium a model belongs to is problematic in many cases—what is the medium of the text wheel in Chapter 5? It consists of some diagrams, some pages of German text and some interpretation and application by others.[116] Can we get anything more fruitful than that out of questioning media modalities of models?

In Chapter 3, an iconic understanding of modelling is used to better understand the relationship between intrinsic and extrinsic features, related to the interplay between factuality and fictionality in

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system) and the modelling system (what is here called a media product is the model). However, the representation function found in MTT is here complemented by a modelling agent, the modeller/s. That means that our definition extends MTT by replacing representation as a relationship with an active process of pragmatic modelling, including making choices and learning, as discussed in previous chapters. See Orlandi (2019) for a more general discussion of MTT in relation to digital humanities.

115 This is parallel to media products generally: "As being a media product should be understood as a function rather than an essential property, virtually any material entity can be used as one" (Elleström 2018, p. 281).

116 The text wheel model is—textually and visually—originally developed and explained rather loosely in Sahle (2013) as part of a more general discussion of textuality. As an object of scholarly discourse, it 'took a life of its own' and is more often adopted on the grounds of the reception, adaptation and re-presentation by others, be it through journal articles (Fischer 2012), conference lectures (cf. https://twitter.com/torstenroeder/status/1174223317764661249) or training events (e.g., Ciula 2016).

modelling (Section 3.2.1). Indeed, clarifying the relationships between the different configurations of modalities that models assume is crucial to the understanding of modelling as a process of *formation*—as we saw above, this is a process of giving form and it is strongly connected to the affordances of the technical medium and the modalities of the media product, linked to the historical and cultural understanding and habit expressed in qualified media. Understanding the levels of interaction between these configurations is also important, as is understanding aspects of control and how media systems steer modelling processes. There is always mutual control between a tool and a modeller. Echoing early communication and media studies theories (Culkin 1967) which assert a mutual shaping between media and subjects, we control the model we make; yet, we are also controlled by technological affordances of the (formal) language, tools, and systems we use for modelling.

All mediated models are media products in Elleström's terminology. This claim hinges on the concept of mediation and the understanding that anything mediated implies physical carriers and display devices, be it a computer disk, a paper scroll, or two screens emitting light and two loudspeakers producing sound as in the case of VR head-mounted displays (HMDs). Still, modelling understood in this way cannot be disconnected from human thinking activities. Models as media products materialise conceptual objects, enabling sharing and negotiation of them. Indeed, the models-as-media-products are in constant interaction with models-in-the-mind as they mutually shape each other.[117] We find an example of this in Chapter 3, where the combination between a reading of a text as a sequential object and a two-dimensional painting was used to form a mathematical, but also spatial, network model (Section 3.3.2). This is in line with the basic assumptions we saw in Elleström's view on the role of media products as a sort of cognitive transport device used in communication between producing and perceiving human minds,[118] bearing in mind how the modalities of the transport device strongly influence the process. The mediated materiality of the three pre-semiotic modalities meets the meaning-seeking mind of a human (the interpreter) in the semiotic modality.

117 On different materialities of models in life sciences, consider the difference between synthetic models and model organisms, see Knuuttila and Loettgers (2018).

118 See also Nersessian (2008).

A digital model can also be experienced in a non-digital (analogue) way, but the manipulation of the digital form and examining how this relates to different modalities lies at the core of digital humanities research. Clarifying the relationships between—and the levels of interaction with—the different configurations of modalities that models assume is crucial to the understanding of modelling as a process of analysis, formalisation and translation.

4.4 Modelling and Media Modalities

Example 1 (Figure 4.1) is a digitised version of a drawing made during the excavation of the ninth-century Oseberg Viking Ship in 1904–1905 (Eide 2018). This is a descriptive or illustrative model of an assumed configuration of the ship in the mound where it was found—but not at the time of the excavation. It is a hypothesis for how the ship was placed originally. It also includes traces of a later event, namely, a mediaeval plundering of the burial. What is shown on the drawing are two different idealised views of a speculative position of the ship that were never seen by the archaeologists doing the excavation but are hypothesised (modelled) based on material evidence. The drawing is a model of two specific events: the burial and the plundering. It is also a model of an idealised state of the buried ship in the mound extended in time from burial via plundering to excavation.

As a digitised version of a paper drawing, the model is easily accessible online and can be studied in great detail. One can zoom in to see the fine details. As the drawing is scaled, one can also read out measurements of the whole as well as the parts of the ship as assumed by the modeller. The texts add a basis for interpreting the drawing based on scholarly assumptions: it is depicting the ship "som det oprindelig maa ha staat i haugen",[119] indicating that the model is well founded but not based on direct visual observation.

119 "As it originally must have stood in the mound".

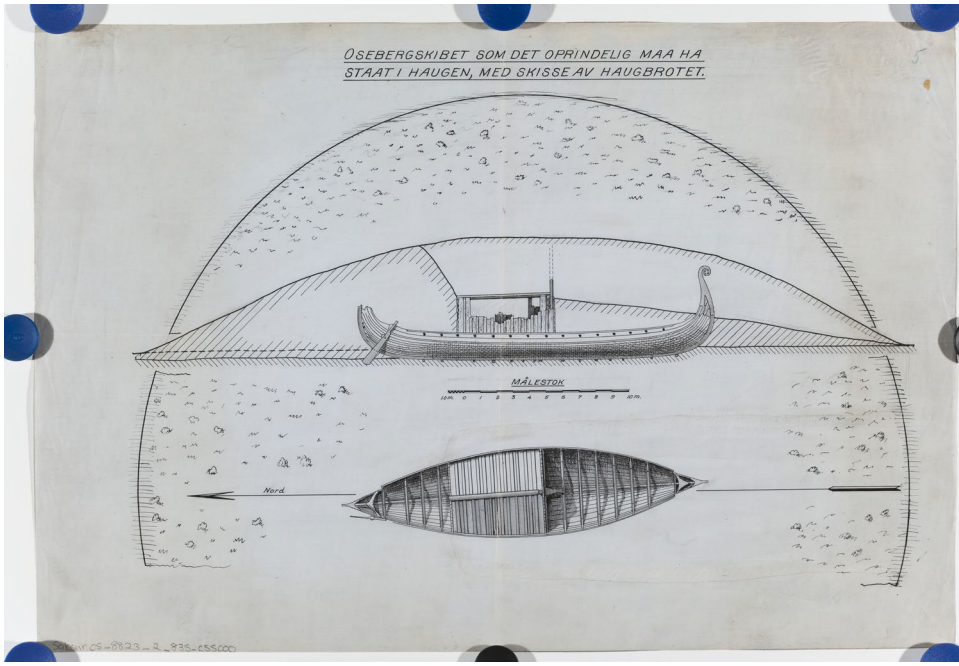


Fig. 4.1 Example 1: A spatial model of the Oseberg Viking Ship. Museum of Cultural History, University of Oslo, Saksnr 05_8823_2_835_C55000.

Example 2 (a fragment is included as Figure 4.2) is a predictive model of the same Viking ship discussed in Example 1 above (Hørte et al. 2005). This so-called strength model of the ship is based on input from many different sources, including 3D scans, manual surveys of damage, testing of material properties of the ship itself, other items uncovered during the excavation, as well as other studies of preservation of wooden constructions as they are known from the literature. The development of the strength model was supported by consultation with experts in archaeology and preservation as well as the skills of the engineers who wrote the report, including extensive experience in writing reports used in the certification of modern ships. The strength model is also called a calculation model, which highlights its dynamic aspects. The model is illustrated in Figure 4.2 reproducing a figure from the report, which "illustrates the implementation of material category 0, 1 and 2 with material properties being assigned to different elements in the model" (Hørte et al. 2006, p. 17).

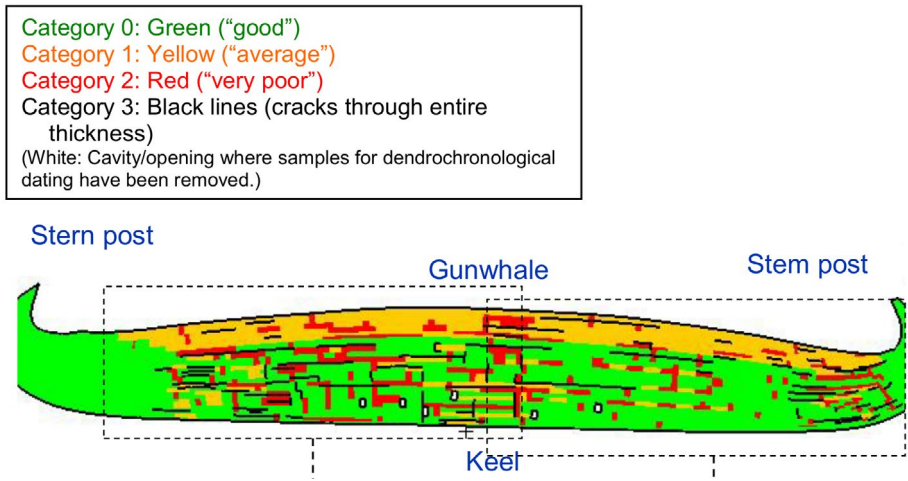


Fig. 4.2 Example 2: “Implementation of material category 0, 1 and 2, plus through-thickness cracks. The figures indicate the position of the ribs” (Hørte et al. 2006, p. 19).

The model is created as a so-called ‘element model’ consisting of a large number of elements representing parts of the ship, that is, parts of planks and other wooden structures. Each element is spatially connected to other elements; each connection is modelled as a separate link connecting the elements. The model is used to evaluate the current stress situation for the ship and make predictions of its future stability, linked not only to the need for better physical support but also to a possible future movement of the ship. The predictions have been used, also politically, as a basis to justify certain actions. The material form in which the model is made available is a written report with illustrations and mathematical formulas available as a PDF document in two versions: Norwegian and English (ibid.).

Example 3 is the text wheel in Chapter 5. This model tries to explain what text is. The simple starting point takes up the production of texts, where a message is conveyed first through expression in a certain language and then through communication by means of some form of media. Within the modelling process, questions of identity arise: how can a model ensure that it leads to functionally identical or equivalent representations of its target? For the example of text: how can a model guide us in representing a text (the target) so that the result can be

accepted as being "the same text" (an instance or application of the model)?

Obviously, the identity criteria depend on single textual features that are claimed to be either essential or arbitrary. To the three understandings of text as content (as message), as verbal expression (in language) or as physical object, further notions can be added. Text as work, as a certain version, or as a complex visual sign can be placed in between these three textual axes. With this, the model names, marks, positions, and relates stances towards text, perspectives on text, and strategies of representation of text.

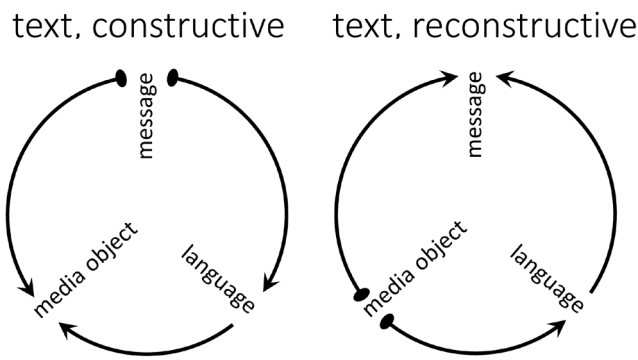


Fig. 4.3 Reduced basic model for the text wheel model.

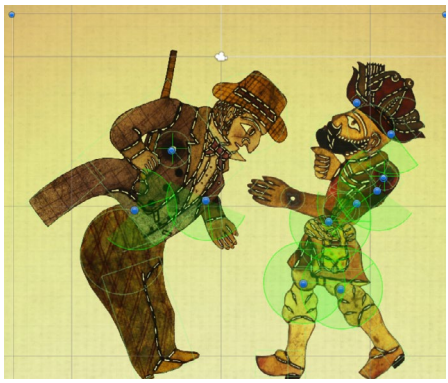
As a map visually depicting six prominent understandings of text, the model allows for further differentiation and the location of other notions of text. It is basically a map to locate other understandings (or models) of text and thus mainly a metamodel in the sense indicated in the Introduction to this volume. It may conceptually recall/resemble an understanding and model of text which includes different forms of textual representation on a scale between originality (close to the material artefact) and usability (close to the interests of a reader) – see Chapter 5. This model has to be circular in order to connect the two perspectives that are positioned at the extremities of the scale and thus could suggest a naïve understanding which is actually questioned by the model itself: that the message (the semantics) of a text is closely related to its visual appearance when it comes either to the expression or the reception of a textual message. The choice of a circular form of the visual model provokes questions around distance from/to a core

essence of text (what is the core?), inner and outer orbits, or the exact place and distance between named positions. In the transformation from verbal description to diagram, it emerges that the model is essentially a map that allows for locating and relating items (which are themselves models); therefore, our literacy in reading diagrams, and indeed our modelling literacy, may also bring about/trigger further unintended (yet potentially productive) interpretations. The text wheel represents a more complex example of models, as media products materialise and interact with conceptual objects. It is further discussed as a use case for modelling studies in Chapter 5.

Example 4 consists of an interactive model of two puppets (the *Frenk* and the *Karagöz* figures (Figures 4.4 and 4.5) used in Turkish shadow theatre. They were initially scanned by Enes Türkoğlu from the original object, held in the Theatre Collection of the University of Cologne. The idea behind the modelling of these objects was to move beyond the traditional digital online museum catalogues, which include descriptions of objects with static illustrations, in order to give prominence to the cultural and expressive context of the objects (Türkoğlu 2019). The Frenk figure (Figure 4.4) is a wannabe European, which is reflected in his looks, based on the historical and cultural context surrounding the development of this specific shadow theatre tradition in Turkey. He is often depicted as greedy and open to lucrative deals. The target of this digital model (i.e., the physical puppet in the museum) has a hidden hand which, with the right level of momentum, can be swung out. This hand is used to quickly close a deal or demand money. This effect does not work with the original figure as the mechanism is partly damaged and interventions to repair it are not feasible due to the fragility of the object.

Since its establishment, the Theatre Collection has sought to act as a laboratory for interaction with real objects connected to theatre. Given the fragility of the objects, this aim is hard to fulfil. In order to re-establish the main original purpose of the collection, it was necessary to create new objects, that is, to transfer their functionality to new objects. The decision was made not to make a physical replica, but rather to establish the new object in another medium.

The model was developed by Enes Türkoğlu in the computer game engine Unity and can also be manipulated using that tool.[120] The simulation was created partly based on the affordances of Unity, the sprite system, and the configurability of that tool. It was also based on scholarly knowledge and personal experience of interacting with such objects in the cultural setting in which they are used.



Figs 4.4 and 4.5 Reproduction of two digitised Turkish shadow puppets in performance modus in Unity. The Frenk figure is to the left and the Karagöz figure to the right.

Employing this platform, the active and creative play with the puppets in shadow theatre can be simulated. This is accomplished not just by modelling the objects themselves, but also by modelling the joints which are the axes of movement. The joints of the figures can be configured and also restricted, as shown via the green semi-circles and circles in Figures 4.4 and 4.5. The development of collision rules, that is, when parts of the figures can move on top of other parts and when interaction leads to a collision and halts movement, was based on knowledge of physical theatre. When two figures interact it has to be decided what is a collision (thus blocked) and what is not. The hands do not collide, which makes handshakes possible. Also the centre of gravity had to be developed through trial and error until a good level of functionality was reached.

Thus, the physical hand movements made by the puppeteer are modelled as a movement steered by the computational input devices.

120 Unity Technologies: Unity Website, 2022, https://unity.com.

In principle, performances can be staged and recorded in Unity, and users can explore different interactions with the puppets in the digital interface. The movements available in Unity include a reconstruction of the hand movements that no longer work in the original due to damage. Thus, the possible interactions of the digital model go beyond what is currently possible with the original, implementing movements assumed to have been possible in the past. Light and sound effects are not included in this model but there are no technical reasons prohibiting them – these are done with other digital models used in theatre studies.

Example 5 is a data model of manuscript KBK 2869, 4°, 2 held by Det Kongelige Bibliotek in Copenhagen, representing a draft of Henrik Ibsen's play *Peer Gynt* (first published in 1867). The focus of the example is the modelling behind the digitally transcribed and encoded text, which is complemented by a scanned facsimile of the manuscript and which is published as part of a digital documentary edition (Pierazzo 2011) on the webpage of the project Henrik Ibsens Skrifter.[121] The name of the actual XML file which can be downloaded from this site is DRVIT_PG PG42869.xml.

Data modelling of textual documents based on the TEI Guidelines[122] is a well-understood process which has been central to discussions on digital scholarly editing for decades. For an overview and visualisation of TEI abstract model, see Chapter 5 ("Digital Humanities: Text according to the TEI"). The adoption of TEI as a modelling practice was also discussed in Section 3.2.2 above. The actual data model for the specific manuscript under examination is expressed by the XML structure found in the document itself, that is, in the file DRVIT_PG PG42869.xml. This structure is in line with a grammar expressed in an XML formal description. The formal description was developed as a customised TEI schema based on TEI P4 in SGML and later converted, first to TEI P4 in XML and then to TEI P5 in XML.

121 https://www.ibsen.uio.no/DRVIT_PG|PG42869.xhtml.

122 https://tei-c.org/ See also Chapter 5. See for instance the introduction to Flanders and Jannidis (2018) for a summary with further references as well as Ciula and Eide (2014) for some reflections on the historicity of the TEI abstract model.

The extended XML schema created by the Henrik Ibsens Skrifter (HIS) project and its concrete implementation in the XML file DRVIT_PG PG42869.xml can be defined as a TEI conformant schema and a TEI document, respectively. The model as it is expressed in this XML document is used to show a scholarly understanding of how the draft manuscript for Peer Gynt is written and clarifies the structure of the text of the manuscript as it is understood by the editors. The relationships between this manuscript and the other versions of the text edited by the HIS project can be explored in the user interface which was developed in order to publish the XML document.[123] As of today, the project website presents the model through a text with various typological elements. It features an interactive system which can be used to compare two or more versions of the text, in the form of facsimiles as well as a digital text, and to show details about the complex manuscript. The many alterations of the manuscripts, visible via the interface, are based on what is encoded in the XML document. This is an example of current standard procedure for the publication of complex digital document collections in the form of digital documentary editions (Pierazzo 2011). The structure of the model expressed in the TEI-XML file is in line with the OHCO structure described in more detail in Chapter 5 ("Information Science meets Electronic Texts: Renear et al.") in which encapsulation in an ordered hierarchy is the structural basis for the model ("The OCHO model", Chapter 5).

Figure 4.6 shows a fragment of page 7r of the manuscript, where Peer Gynt and his mother Aase are talking. The fragment is structured as a dramatic text with verse lines, some of which are shared between the speakers. It includes changes to the text within single lines, as well as larger parts that have been removed and replaced. It also includes an added part written in the margin.

The XML coding, partially shown below, includes both standard TEI elements such as 'speaker', 'app', and 'l', and extensions/alterations to

123 The relationship between the different manuscripts and editions of Peer Gynt was not encoded within the HIS project. Given the differences between the draft manuscript discussed here and a later manuscript called the print manuscript ("Trykkmanuskript", KBK 262, 4°, I.2) used as basis for the first edition, this would be a significant task, which might be enabled by tools which were not available at the time of the project.

TEI which are in the HIS namespace (starting with 'HIS:'). The dramatic structure of speeches and speakers, the line structure with verse lines, as well as the alterations, are all recorded in XML, using XML elements from TEI and from the HIS extension.

Based on the information from the manuscript modelled and expressed in the XML-TEI file as well as the stylesheets used to convert it into HTML, the web system shown in Figure 4.7 is generated. The encoding in the XML files are used to generate the formatting of the dramatic structure as well as the line structure and the modifications made to the manuscript. This is a typical way of using data modelling in order to make editions with TEI-XML. The letters and words found in the manuscript are transcribed into the XML document. The organisation of the play, with verse lines and the dramatic structure, are encoded, and the modifications made to the manuscript are encoded according to criteria and a level of granular detail agreed by the project team. Not all words can be easily read; in some cases, certain letters or words are tagged with 'unclear'.

By modelling the manuscript in this way, the project achieves its operational goals: the text can be presented online and in print with variations; it can be connected to other versions of the same text, and the encoding can be used for some forms of text analysis and indexing. At the same time, the different levels of information are formalised in a way which clarifies certain aspects of how Ibsen wrote his manuscripts, while distinguishing those parts of the manuscripts which at the time of encoding were considered not to fit with any existing elements of TEI (the additional elements preceded by the 'HIS:' prefix). As discussed in Section 3.2.2, the modelling typically takes place in cycles, leading to models fulfilling the ever-refined and often shifting goals of the project, as well as to a deeper understanding of the form and structure of the manuscript and how it establishes meaning. In this case, this process of modelling is not made explicit in the online edition, but is documented in the 'revisionDesc' element in the TEI header of the document through notes about changes, corrections, updates, validation, re-coding, etc.

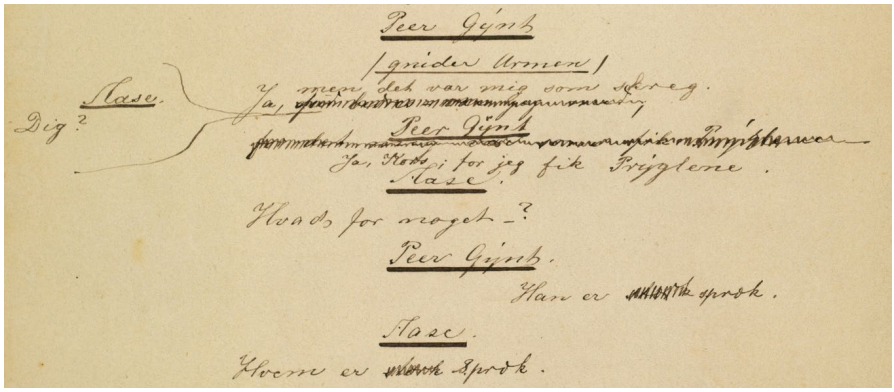


Fig. 4.6 Fragment from KBK 2869, 4°, 2, page 7r.

Part of the XML encoding of the fragment above:

```
<HIS:hisSp who="PEERGYNT">
    <HIS:spOpener>
        <speaker>Peer Gynt</speaker><lb/>
        <HIS:hisStage>(gnider Armen)</HIS:hisStage>
    </HIS:spOpener><lb/>
    <l>Ja,
    <app type="alteration">
        <lem>
            <HIS:hisAdd place="offline">men det var mig som
            skreg.</HIS:hisAdd>
        </lem>
        <HIS:hisRdg>
            <HIS:hisDel rend="overstrike">Gud bedres – var
            jeg med</HIS:hisDel>;
        </HIS:hisRdg>
    </app>
    </l>
</HIS:hisSp>
<HIS:hisAdd place="margin"><lb/>
    <HIS:hisSp who="AASE">
        <HIS:spOpener>
            <speaker>Aase</speaker>.
            </HIS:spOpener><lb/>
            <l part="I">Dig?</l>
    </HIS:hisSp>
</HIS:hisAdd><lb/>
<HIS:hisSp who="PEERGYNT">
```

```
<HIS:hisAdd place="inBetweenLines">
<HIS:spOpener>
        <speaker>Peer Gynt</speaker>
        </HIS:spOpener>
</HIS:hisAdd><lb/>
<app type="alteration">
        <lem>
                <HIS:hisAdd place="infralinear">
                        <l part="F">Ja, Kors; for jeg fik Pryglene.</l>
                </HIS:hisAdd>
        </lem>
        <HIS:hisRdg>
                <l>
                        <HIS:hisDel rend="overstrike">for det
                        <unclear>mig</unclear> var
                <unclear>som</unclear> fik Pryglene</
                HIS:hisDel> –</l>
        </HIS:hisRdg>
</app>
</HIS:hisSp>
```

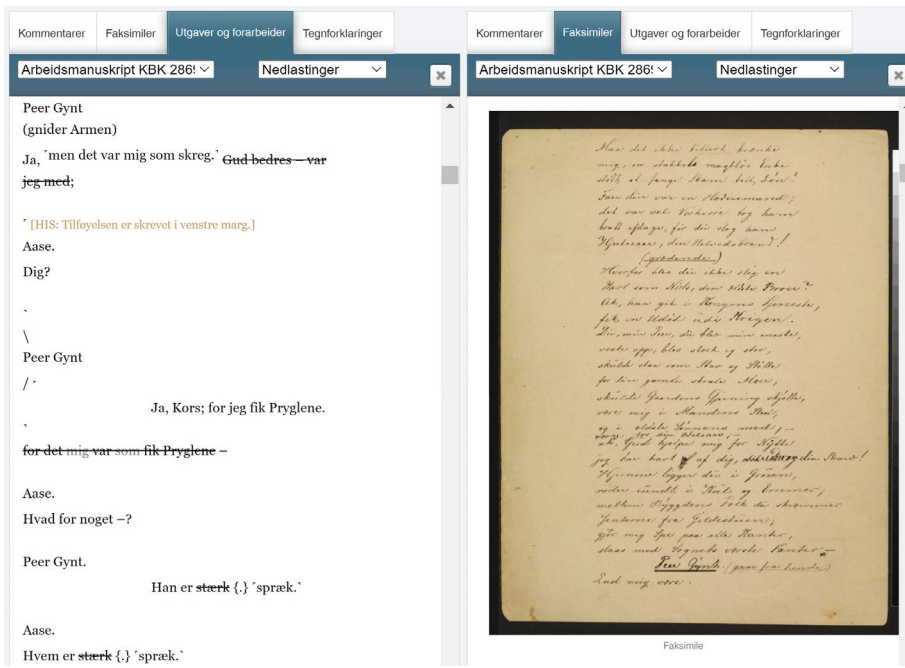


Fig. 4.7 Web version of the fragment from above, showing the text with amendments in a so-called parallel view, with the facsimile next to the text. Note that all parallel views also include the edited text, which is omitted here.

In all these examples, modelling processes resulted in media products, that is, in the models. The technical medium of the model has a number of characteristics which influence what can be expressed by the model, but it does not determine the function and meanings of the model. Indeed, aspects of the qualified medium also have a role in the creation and use of models. The concept of the technical medium relates to the technical limitations and possibilities (affordances) of the model, while the concept of the qualified medium encompasses the cultural expectations, or the modelling literacy, of those creating and using the model. Such expectations are based on our media experience and can always be challenged; technical limitations can change over time too. We see that computer-based models have possibilities for interaction that paper-based models do not have, but also that a 3D model has affordances that a scanned drawing does not have. Thus, the affordances are only partly dependent on whether the media product is digital or not. In what follows, we will organise some of these affordances based on the modalities of the media products.

There is no general quality or value hierarchy in which to order types of models based on their technical or qualified media. The stress model in Example 2 was costly—the job was paid for by the museum—so it is more valuable than the drawing in Example 1 in the sense that the financial cost of making it was higher. However, the drawing provides a clear overview of the burial setting that the stress models do not offer. In cases where such an overview is needed, the drawing has a higher value. As our understanding of modelling as pragmatic acts makes clear, a model value may be assessed in light of the purpose of the modelling activity from which it originated as well as the context of its use.

Models seen as media products are analysable using the system described above. This approach can be used for single models as well as for classes of models. In some cases, classes of models could be linked to or even establish qualified media. In Fig. 4.8, the media modalities are used to analyse and compare the five examples. For each of the modes introduced above, a plus or minus sign indicates whether a modality is present or not, while a pair of parentheses indicates that the presence of that modality is partial or reliant on specific conditions or perspectives. However, presence or lack thereof does not in itself show how a mode functions. The specific ways in which the modes are used will be discussed further below.

Modality	What the modality is	The most important modes of the modality	Oseberg drawing	Predictive model	Text wheel	Puppet in VR	Ibsen manuscript
Material modality	The latent corporeal interface of the medium; where the senses meet the material impact	1. human bodies	–	–	–	–	–
		2. other demarcated materiality	+	+	+	+	+
		3. not demarcated materiality	–	–	–	–	–
Sensorial modality	The physical and mental acts of perceiving the interface of the medium through the sense faculties	1. seeing	+	+	+	+	+
		2. hearing	–	–	–	–	–
		3. feeling	–	–	–	–	–
		4. tasting	–	–	–	–	–
		5. smelling	–	–	–	–	–
Spatiotemporal modality	The structuring of the sensorial perception of the material interface into experiences and conceptions of space and time	1(a) space manifested in the material interface	+	+	+	+	+
		1(b) cognitive space . . .	+	+	+	+	+
		1(c) virtual space	+	+	(–)	+	(+)
		2(a) time manifested in the material interface	–	–	–	+	–
		2(b) perceptual time . . .	+	+	+	+	+
		2(c) virtual time	+	+	–	+	(–)
Semiotic modality	The creation of meaning in the spatiotemporally conceived medium by way of different sorts of thinking and sign interpretation	1. convention (symbolic signs)	+	+	+	+	+
		2. resemblance (iconic signs)	+	+	+	+	+/–
		3. contiguity (indexical signs)	+	(+)	–	(+)	–

Fig 4.8 Overview of the four media modalities (Elleström 2010, p. 36) applied to five examples of models.

In the material and sensorial modalities, all five of our examples engage the same modes. All of them are documents on paper or on computer screens and thus have materialities that connect primarily to sight.[124] This is not just common to these five examples: models in many parts of the humanities tend to be conveyed via flat spatial documents consisting of texts, illustrations, etc. This is different in areas such as architecture, design, musicology, theatre, and performance studies. In modelling activities as communicative acts where models are shared and critiqued, moving human bodies and body parts, hands, fingers and human voices have a role too (Nersessian 2008; Ochs 1994). But they are not generally seen as parts of the models. Media configurations such as dancing bodies and live music are important in specific areas such as choreography studies. Such modalities are also used for public outreach and teaching. Turnbull describes scientific modelling as a process of collective visual communication utilising diagrams and other media products. This shows how performative aspects of modelling are parts of the development of models as a social activity more generally.

A hodological understanding underpins two revealing approaches to the role and use of diagrams; one ethnographical and one analytical. Ochs et al. looked at how experimental physicists work collaboratively and found that they use "visual representations and models to create a virtual space in which they can travel as a hybrid construction of themselves and the objects they are attempting to explain and understand" (Ochs et al. 1994, p. 151). Osborn describes diagrams as "tools for learning how to see, how to reason, and how to narrate" (Turnbull 2007, p. 144).

In the spatiotemporal modality there are some differences between our five examples. In all five of the examples, space is manifested in the material interface. In three of the examples virtual spaces are also created, but this is not the case for the Text wheel example, which instead spans a "conceptual space". The occurrence of a virtual space mode can be argued for the Ibsen manuscript example, as XML documents represent

124 One could claim that a model with which one can interact on a computer includes, as part of the intended interaction, the sense of feeling one has when using, for instance, a keyboard or a mouse. These devices are however dependent on individual setup and circumstances; issues of accessibility are not really addressed here either. A more rigorous application of the modelling function outlined above would require the examination of the circumstances of the interpreter (e.g., how would a deaf subject experience the modes of these models?).

tree hierarchies with specific culturally and scholarly agreed upon visual forms expressing the structure of the schema and the document. Furthermore, the spaces manifested in the material interfaces and the present virtual spaces are different, in ways that relate strongly to the semiotic aspects. Indeed, the spatiotemporal modality works here as some sort of transfer mechanism from the material modality met by the senses to the meaning.[125]

Only the puppet model has time manifested in its material interface; the other four examples are static documents, with the nuanced case of the web interface for the Ibsen manuscript, which also has interactive elements, manifesting time in the material interface. The time is not fixed in the puppet model nor in the web publication of the manuscript; the movement patterns included in the interfaces of these two models rather imply that movements can be played out in time. While the reading of a PDF document, and indeed of a printed book, includes browsing from page to page, this movement is a fundamental part of the activity of perception and is part of the perceptual time of the spatiotemporal modality only. The interactivity of the VR interface is essential to the perception itself, in that the actual message is changing with the interaction, rather than the interaction being necessary to get to content that is static. The interactivity of the web interface of the manuscript might be less essential to the use of the model (one could still read the static document without engaging with other elements of the interface), but it is still a core aspect of the usability of the system. These movements in time can be seen on a computer screen or, in the case of the puppets, also in a head-mounted display (HMD).

The models afford different types of interaction in time—perceptual time is present in all cases but is experienced and used differently. In virtual time we see further differences. The Oseberg drawing manifests two different periods, as expressed in the caption: the state of the ship in the mound and the shaft used for the plundering, which took place over a much shorter period. The predictive model describes both the past and possible futures of the ship in the museum. Thus, it functions as a model telling stories, also about the future, which creates a virtual time.

125 Transfer here does not suggest a movement from modality to modality. The transfer is an analytical link between the two other parts of the modalities (Eide and Schubert 2021, pp. 189-190).

The text wheel refers to textual objects without laying out a specific development over time; therefore, the time here is mainly perceptual. While there might be underlying synchronic aspects, these are not central to the model. The wheel suggests an arbitrary sense of order of reading in time: you start somewhere and then proceed to other places on the wheel, creating and negotiating relationships between the different positions. In fact, the sight of a material object, the reading of words and sentences, and the construction of the meaning of a text based on the reception all happen reciprocally, alternating between senses that are different, but still connected and mutually interacting. In some uses of the wheel, arrows are added to show a specific reading order, indicating an intended direction of the perception. The puppet model has the potential to be used to perform theatre plays. Thus, a non-fixed, virtual time is inherent to the interactive potential of the model. The XML structure of the manuscript model is not in itself time-based, but the order of the XML elements is connected to the time inherent to the narrative.

Semiotically speaking, all of the models use symbolic aspects of signification, both in textual and graphical form. The puppet model also represents personal and cultural aspects of a stereotypical person through visual resemblance and convention, in addition to what digital puppet theatre players manipulating the model can do, for instance, in describing the character as part of the storytelling dimension of the model.

In the Oseberg drawing, the iconic aspects are in some sense creating an image-like link to an assumed reality—but it also has clear structural aspects. The text wheel is a structural icon (a conceptual map or a diagram) with metaphorical aspects. The predictive model expresses complex iconic relationships through its pictorial and diagrammatic representations as well as mathematical formulae. The focus is on structural similarities, but there are also clear image-like aspects, as well as some level of metaphor. We also saw a similar example of structural similarities in the text–map example in Section 3.3.2. The puppets in VR manifest an image-like similarity with the originals, both in the static form and in patterns of movement. The XML structure of the TEI model of the manuscript is iconic to a tree structure and the general abstract structure of a graph.

The scale of the Oseberg drawing enables a map-like index where the metre scale indicates an implicit indexical grid. As for the predictive model, it includes 3D scans and digital photographs which can arguably be seen as indexical (Lister 2007). The modelling of the puppet creates a similar potential for indexicality.

4.5 Modelling as Media Transformations

The perspective taken in the previous section clarifies that the process of modelling is not simply a free selection of features from the target, but rather a process where the chosen set of features in their selection and form are partially steered by the affordances of the medial form used to express the model. The affordances of the medium contribute to the definition of the factual aspects of the model. This is the case for all modelling, also in the sciences, and is closely linked to how tools shape senses, knowledge, and actions. Indeed, the process of creating a mediated model by translating selected aspects from the model target is at the core of research processes, as discussed in Chapter 3.

To get one step further towards an understanding of the mediality of models we can ask how the modelling process itself can be analysed using the language of intermedia theory. Insofar as the target of the model is itself a media product or a technical or qualified medium, the process of modelling can be conceptualised as a media transformation based on the same framework from intermedia studies.

The degree to which it makes sense to see the target of modelling, the objects and/or processes being modelled as some sort of medium varies. In the humanities, we often make models based on one or more expressions which are clearly media products.[126] In those cases, the modelling activity is not just influenced by the modalities of the model but also by the modalities of the target and the relationship between the two sets of modalities. The process of modelling can be seen as an act of translation between two or several media products, or between a

126 This is not exclusive to the humanities. Also, in the sciences targets of modelling are selected and understood by human scientists or other agents (cf. Section 3.4.2) and it can be argued that a mediation takes place in this process (Daston 2000). However, a discussion of media products in the context of the targets of scientific models is beyond the scope of this book. See Fanjoy et al. (2012) and Shin et al. (2018) for discussions of the use of diagrams.

qualified medium and a media product: a model can be based on one or more works, or on larger groups of works. In the context of intermedia studies, using the theoretical framework introduced in the beginning of this chapter, such translations are called media transformations (Elleström 2014). While media transformation processes are *studied* in intermedia studies, they are *performed* in scholarly modelling.

Media transformation is not a process of transformation in the sense that the source is being modified into the result, as in the case of transforming a block of marble into a statue. It is rather a process of creating one media product based on aspects taken from either another media product or from a qualified medium. Here, we will introduce a model for media transformation based on Elleström (2014) and its application to modelling in Eide (2015, pp. 195-198) showing how it can be used to better understand modelling.

Media transformations are analytically divided into two groups: transmediation and media representation. Transmediation denotes the creation of an impression in one media expression, the *target*,[127] based on another expression in another medium, the *source*. A typical example is film adaptation, where the narrative structure from, e.g., a novel is recreated in a film. Other examples include a painting of a crying man picking red flowers being reproduced as a scene in a film, without showing the painting itself.

Media representation takes place when one media product is represented in another medium. A typical example is when a painting is seen in a film. Textual descriptions can also be the result of processes of media representations, as we see in the long tradition of ekphrasis, where works of visual art are described in poetic texts. The source of media representation does not have to exist in reality: a novel describing a photograph taken by one of the fictional characters is also an example of media representation. Transmediation and media representation are often mixed, except for in cases of pure media representation, where no transmediation between the two media expressions takes place.

In the context of scholarly and scientific modelling we also find media transformations not directly connected to the target of the modelling

127 This is a different use of 'target' than that which we find in discussions about modelling (a 'model target' is intended usually as the object being modelled or in fact as the source of modelling), and elsewhere in this book.

process. Often, modelling includes a series of representational stages. Three examples will show how this works; the first is taken from mathematical modelling, the second from philology, and the third from modelling in media studies. These examples also relate to the discussion about the relationship between reduction and expansion in modelling (Section 3.2) and the integration of formal (rule-based) modelling with interpretative visual and verbal expressions (Section 3.4).

In the work of Gregor Gassner and colleagues on numerical modelling of real-world phenomena,[128] one of the application areas is Tsunami warnings. While this research is based on a natural condition as a starting point, it goes through a number of models, each building on the previous one. This series is an example of what we intend here with modelling as media transformations. The natural phenomena (target) forming the basis for the chain of models is open sea with water, landforms, variation of sea floor elevation, etc. This is expressed scientifically in the form of a physical model of relevant aspects of the environment. A mathematical model is then created, which represents the aspects of the physical model—and thus also of the physical environment being modelled—needed for the research. As this mathematical model cannot be used in real-time simulations while volcanic activity is taking place, a numeric model based on it is made, with enough details to give useful predictions, but still limited enough to make calculations possible within the timeframe. This numeric model is then used in a simulation where predictive results are obtained, which can then be communicated to authorities in charge of counter-measures along the coast in the form of visualisations, accompanied by recommendations in writing. Thus, what we see is a series of models, each based on the previous one, which are all transitive, so that the end result is also a model of the real-world environment and processes therein:

(*world* →) *physical model* → *mathematical model* → *numeric model* → *results from modelling* → *visualisation*

128 The description here is taken from a presentation by Gregor Gassner in the lecture series of the Centre for Data and Simulation Science at the University of Cologne on 8 May 2019, http://cds.uni-koeln.de/en. The research which formed the basis of the aspects highlighted here is published in the 2018 PhD thesis of Niklas Wintermeyer, https://kups.ub.uni-koeln.de/9234/.

As in the stress model of the Oseberg ship, the main purpose of this model is to influence future actions.

A visual series of stepwise formalisation, which is basically a media transformation from mediaeval manuscript writing to interpretative and explicit vector graphics (SVG), can be found in an ongoing project of one of the authors (Sahle) shown in Figure 4.9. Here, a representation of Noah's Ark in a manuscript of Peter of Poitiers' *compendium historiae* is converted stepwise to a form which is visually similar (in the sense of image-like resemblance discussed in Chapter 3) but most of all structurally isomorphic. The Ark here is basically and conceptually represented as a 'three-storey-thing' with three top sections (mild animals, humans and birds, wild animals), two mid-sections (store, dump) and one lower (bilge) section and a door (to the left). If formalisation is the distinction between arbitrary and essential features of the target, which is a specific historic media expression in this case, then 'stepwise' involves eliminating, abstracting or normalising specific features or properties one by one. This regards, for example, historic and individual expression and aims at the general conceptual structure which then is valid not only for this manuscript but for the conceptual understanding of the Ark according to certain textual sources.

Fig. 4.9 Critical stepwise formalisation of a diagram of Noah's Ark from Peter of Poitiers, *Compendium Historiae*, here detail from British Library, Ms. Harley 658, fol. 33r (c. 1200/1225).

A similar approach can be observed in so-called critical stepwise formalisation, in which a media expression is studied via the process of adapting it into a new expression in another medium step by step (Eide 2015, in particular Chapter 3). The main structure is in line with what we just observed in the example from mathematical modelling above. The starting point is the media products under study. Based on this starting point, a model is created, and refined through steps which are expressed in different formalisms, until an end result in another medium is created. The application in Eide (2015) was a process of transforming a text to a map, as visualised in Figure 4.10. We see how interpretations

of a text fragment are expressed differently in a number of formalisation steps up until the end result, which is a graphical representational expression: a map. A large number of such expressions linked together make up a model of a terrain as it is expressed in a text, with the spatial information in the text as the starting point (or the source in Elleström's terminology) of these transitive modelling steps.

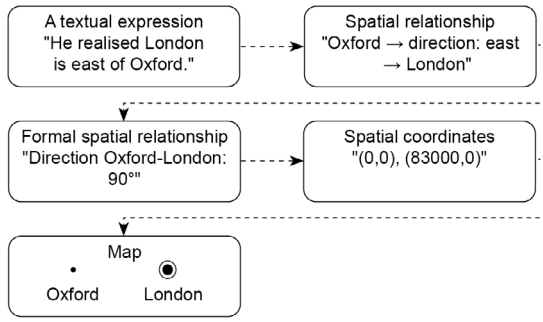


Fig. 4.10 Critical stepwise formalisation example (Eide 2015, p. 43, Fig. 3.1).

Unlike the tsunami warning modelling above, the main aim here is not the end result—the last model—but rather what can be learned from the process. Modelling as media transformation works differently in different research contexts, and the goals can be quite different, but in all cases each of the models is a media product with a set of media modalities different from the models it is based on and from the models based on it, and the process is transitive, so that the end result is taken as a model of the starting point. This does not mean that the process of creating and using such a modelling structure can be seen just as a directed and linear series of stages. According to a media transformation-based view on modelling, each stage can also be seen as part of a larger modelling effort consisting of phases and iterations of reduction and expansions as expressed in Section 3.6.

One important part of such modelling in the humanities, as exemplified in the map example, is to identify and interact critically with aspects of the objects and processes of study that are difficult to formalise. What are meaningful media products for a competent human are symbols to be shuffled for a computer. The lack of understanding on the side of the computer system on which we develop and run our models makes many tasks hard to automate, but can also be seen as a

positive affordance in that it has the potential to make the specific steps in the processes of decoding media products more visible to us. The process is often glossed over in human meaning-oriented interaction with media products. Using a computer-based modelling tool, we are forced to make explicit steps that are often glossed over in the internalised processes of establishing meaning that humans apply when they interact with media products.[129] "In digital humanities we exploit the fact that computers are less goal oriented than we are, less framed in sympathetic exchanges with desire for meaning, so they can help us to find other readings than the ones we see" (Eide 2015, p. 57 footnote 24).[130] As pointed out by Gelfert (2016, p. 113), such a view on models as concrete objects is different from seeing models just as mediators, for instance, between theory and data. The mediality and thus also the materiality of models (their factuality) can be used to reason with and learn from in relation to their fictionality and agency, a point also noted by Knuuttila:

> [I]n the recent discussion on models, the earlier emphasis on representation has been replaced by the attempts to approach modelling from a mediative and productive perspective. A central move taken by that approach is to consider models as independent entities that can be used to gain knowledge in a multitude of ways. (Knuuttila 2010, p. 168)

While all humanists engage with digital media products, it is in the digital humanities that the translations from analogue to digital forms and vice versa are problematised in epistemological terms and undertaken with the research aim of operationalising a concept. Seeing modelling as processes of media transformation pinpoints how the epistemological functions are dependent on the media modalities of the models. Where a specific piece of work is located on the scale between mass digitisation and hand-crafted modelling is not just based on technical and logistical possibilities but also on the relationship between the configurations of the media modalities in the technical media. Similarity can vary and it is not the aim here to make clear borders between what is modelling and what is not based on an analysis of the relationship between model and

129 There is a long discussion over this aspect of computer use in the DH literature, see, e.g., section V of the TEI Guidelines https://tei-c.org/release/doc/tei-p5-doc/en/html/SG.html, and McCarty (2005, p. 5).

130 This is also related to the discussion of agency in Section 3.4.2.

target. Rather the opposite: the context of a process of the creation of media products, with its operational and epistemological goals, is what characterises it as modelling. The choice of frame of understanding is based on production systems, media modalities, human expertise and choices, and more generally—the context of usage and analysis.

How the media modalities work in a source medium as opposed to in the target medium is important for understanding how a media transformation is influenced by the two media. Media modalities can be used to understand how transformation processes have systematically different affordances based on the configurations of the media modalities in the source and in the target media. These differences can be strongly linked to changes in the material and sensorial modalities, for instance, when written words and graphics are used to express the structures of music as it is found in audio recordings or in graphical markup languages for dance. In other cases, the differences we see in the transformation are mainly connected to the semiotic modality, as in the map example above. A further discussion can be found in Eide and Schubert (2021).

When the material and sensorial modalities are fairly stable between target and model, an integration in the same expression is quite easy, like a map modelling a text or a graph modelling the reproduction of a painting. A transfer between time- and space-based material modalities, on the other hand, can lead to documents with quite different forms, but in such cases content elements can still be translated without too many obstacles, as in the performance of a musical score or the reading aloud of a written text. That said, it is important to remember that all modalities interact in media transformation processes. More research is needed in order to move towards a classification of modelling practices along the lines of media modalities.

4.6 Mediality as Affordances in Modelling

In Chapter 3 we saw how in the example of metaphorical iconicity, model targets of two different media (text and image), complemented by contextual knowledge and other sources, result in a media product of a third medium (network). The relationship between model and model target is complex and evasive, as are the two categories themselves.

Using semiotic and intermedial frameworks, we have a richer language to discuss these concepts. This enrichment, however, does not make the phenomena and the relationships between them simple, easy to formalise, or identical across different concrete cases of modelling. The possibilities in seeing modelling as media transformations are only indicated here. A larger body of material must be studied in order to generalise the patterns we see here into a model of modelling seen as media transformations.

Our aim with this chapter was to reflect on models and modelling by analysing modelling objects and processes with a focus on their materiality as media products. Accounting for media aspects in modelling also allows us to better understand the consequences of positive and negative affordances being added to a model. The media affordances of the mediated models and modelling process include the limitations and possibilities we know from the long history of inter-art studies, with Lessing's "Laokooon" from 1766 as a central work, into the current study of intermediality, as in Elleström's publications cited above: the models are enabled and limited by the available grammar, lexicon, geometry, and other inherent properties (their factuality). These properties vary from expression to expression, but can be grouped and systematised. Elleström's work has given us a language for such a systematisation which we find useful as a complement to the other approaches presented in this book.

The discussion here is linked to the philosophy of technology and the study of how artefacts function. In the case of modelling in DH: The formal rules (e.g., those given by the computational artefacts we use or develop) and the subject matter rules (e.g., those given by a specific field or domain of knowledge), taken together, provide the means of reasoning with a model in DH research and teaching. The understanding of the model as a media product is mainly used to develop a more nuanced understanding of the formal rules expressed as model modalities. Models as concrete forms with an identifiable level of formality provide affordances to the intellectual process by enabling and constraining the development of *what* can be represented and *how* it can be represented.

This is even more evident when immersive systems such as VR are used in modelling. While such technologies are often used for computer

games and more generally for art and entertainment, they are also used in simulations with the purpose of training and research. They are already important parts of scholarly modelling, as seen in areas such as medicine, chemistry, archaeology, and theatre studies. In the humanities we tend to make our models by using the modalities we have available for visual expressions based on textual data. Other modalities such as hearing, smell, and touch have been less used even if some areas of research, including musicology and archaeology, regularly use hearing and touch as ways of acquiring knowledge. Smell is also used in some areas within the humanities as well as in the sciences.

Creating an adaptable model of modelling is important not just in order to understand more of modelling as it happens today, but also to understand better how it might develop in the future. Seeing models in light of their mediality is a necessary part of developing such an understanding.