Signs of Meta-understanding – a Semiotic Perspective on Multidimensional Ontologies and GI-usability

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Abstract. This paper is addressing aspects of usability and user needs at the meta-communicational level concerning how to facilitate an increased reuse of datasets related to buildings due to a Danish public geo-information management and infrastructure perspective. Lead by the goal of analyzing usability aspects regarding the building object the research design has been based on a systems analysis approach related to use scenarios in a city renewal context. Due to the need of being able to handle various levels of representation and communicational aspects regarding multidimensional multipurpose information systems a modeling tool based on a general semiotic theory of logic has been developed. Within this ontological framework based on the semiotic approach it is possible to categorize and analyze for instance representations based on abduction, deduction or induction as well as use aspects related to the syntactic, semantic or pragmatic levels.

1 Introduction

Due to Danish government intentions of digitalizing the interaction between citizens, enterprises and authorities as means of increasing efficiency and quality in the public management several projects has been carried out. Dealing with those visions of digital management at al levels within the Danish public administration the building object is a geo-phenomenon of key interest. Within the built environment, city planning or city management specialized training, practices and tools have defined specific understandings as well as various ways of handling information and knowledge related to buildings. Though efforts have been made to establish procedures supporting sharing and exchange of building data consensus concerning object definitions has still not been achieved and a major part of the information exchange procedures are still based on paper documents. Redundant databases and lack of efficiency considering data maintenance procedures are among others obvious results. This paper is reporting on a Ph.D.-project addressing the methodological problems of analyzing user needs due to the increasing complexity of information structures and quality demands. Dealing with the hypothesis that a shared multidimensional understanding of the building phenomenon and its expression in various contexts would increase usability by providing a richer semantic framework analyzing different aspects of modeling and representational forms has been a key

matter. It will be argued that a systems analysis approach based on the semiotics of Charles Sanders Pierce, related to Niklas Luhmann's theory of social systems, and accentuated by Umberto Eco's cognitive approach will provide a theoretical framework for discussing multidimensional ontologies and GI-usability as well as communicating various modeling aspects due to the complex needs for metadata, meta-information or meta-knowledge. On this background the concept of meta-understanding is introduced.

2 The semiotic approach

Dealing with multipurpose building information systems al kinds of representations of diverse building phenomena due to models of planning processes, design processes, construction processes or management processes leads to very complex models of communication at the various syntactic, semantic and pragmatic levels. As pointed out by Jonathan Raper (10) the new possibilities of multi-dimensional geo-technologies demands a holistic understanding of GI-Science as an interdisciplinary scientific field and within this common framework reflect on the various concepts of representation. Here it will be argued that the semiotics of Charles Sanders Pierce (1839-1914) provides a very general formal ontological framework (8) with the capacity of systemizing and expressing the various layers of conception, representation and information.

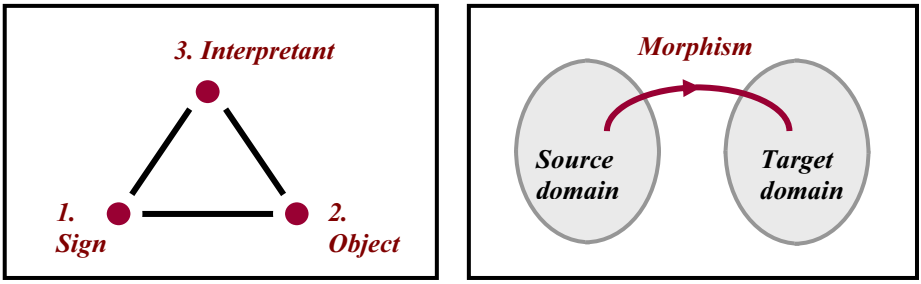
The semiotics of Pierce is of increasing interest as means of understanding the fabric and dynamics of representation as well as the representation of data, information and knowledge (13). Regarding geographical information sciences Raper (10) as well as Peuquet (9) is referring to semiotics in general as carried out by researchers as Bertin and MacEachren. Describing the field of data mining Raper is referring to Gahegans visual approach to the concept of abduction. Pierce invented the idea of abduction as inference based on intuition as a supplement to the traditional logical forms deduction an induction. As emphasized by Kweku-Muata Osei-Bryson and Ojelanki Ngwenyama (7) the data mining technology in its foundation is based on those principles of abductive inference. On the other hand they point out that this technology poses the potential of generating the hypothesis due to the theories of Pierce as well as Popper.

Due to Pierces (8) concept of semiosis knowledge is created during the cognition processes by the analyzis of the sign compared to what we already know about the phenomenon. The semiotic principle of constantly considering the relations between the three basic elements – the representation (*sign*), the object of the representation (*object*) and the way the object is represented (*interpretant*) – establishes an abstract cognitive framework for handling the analysis of the various communicative aspects related to the complex questions of data quality and metadata.
Due to a basic triadic principle Peirce (8) developed a semiotic ontology of 66 sign categories based on a formal logic defining the possible types and triadic combinations. The most common triadic categories are:

1. *Icon-index-symbol*, a triad (referring to *ground*) categorizing the three levels of representing the relation between the sign and the represented phenomenon (*dynamic object*)
2. *Image-diagram-metaphor*, a triad categorizing the three levels of expressing likeness (*hypo-icons*)
3. *Abduction-deduction-induction*, a triad categorizing the three forms of inference

To be able to handle the various layers of models developing a general concept of modeling has been considered a key aspect. The triad as pictured by Kjeld Gall Jørgensen (4) and the illustration by Michael F. Worboys (13) expressing the traditional mathematical view on models was the starting point (fig. 1).

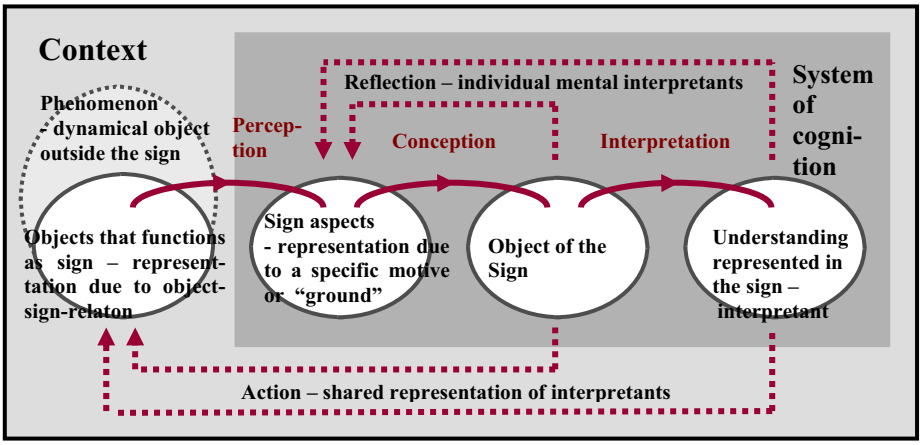
Fig. 1. The concept of the triad by K.G. Jørgensen (4) and a general conceptualization of a model according to Michael F. Worboys (13)



Due to Peirce (8) the basic criteria for any kind of reasoning and communication is iconicity as this is the only way to represent an idea. Frederik Stjernfelt (12) emphasizes the importance of being able to identify the various forms of likeness due to the actual transformation and he emphasizes Pierces concept of diagrammatic reasoning. Combining the idea of semiosis, the triad, the transformation processes with Niklas Luhmanns (6) concept of social systems based on complex communication processes depending on specific codes provides the contours of a general concept of modeling as part of various cognition-, representation-, and communication processes.

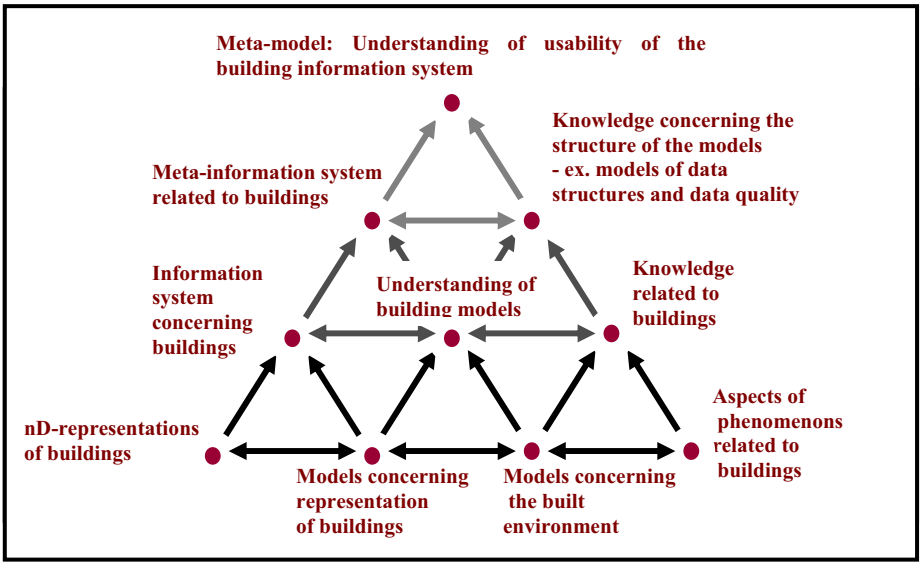
As illustrated in the diagram below (fig. 2) this basic concept contains the idea of a system and a context. The system contains some basic elements: An input-domain, a model-content-domain and an output-domain. The main flow expresses the irreversible transformations performed through the system starting with the selection of input, the modeling process and the mediation process. The internal feedback mechanisms express the act of reflection or revision inside the system while the external feedback mechanisms express the various forms of communication outside the system.

Fig. 2. The sign-model related to the process of cognition



The model is very abstract though it formalizes some general dynamical and representational aspects of modeling and expressing various kinds of data, information and knowledge.

Fig. 3. A triadic approach to conceptualizing layers of models



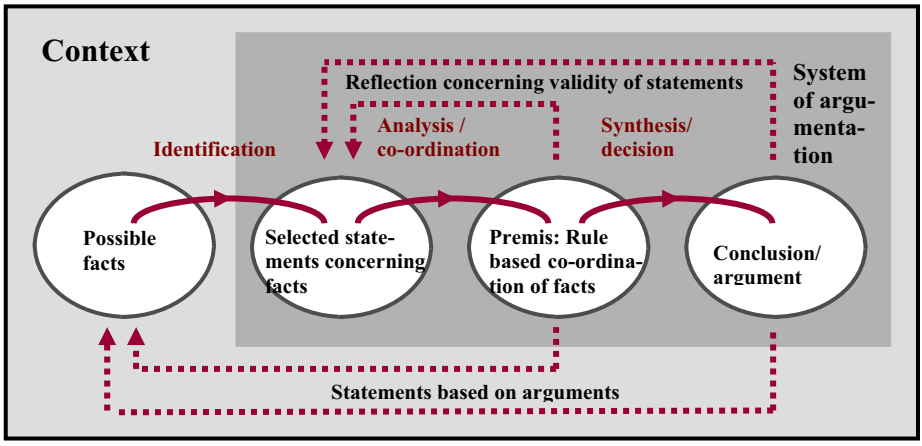
Though this formalized 2D-structure focuses similarly to traditional tools of systems analysis on a specific aspect and a specific layer in the system so various types of diagrams is needed. The illustration above (3) shows an example of a diagram based on an extended version of the triangular model framing the relations between building phenomenona, multidimensional representations of buildings as well as various layers of meta-models.

3 Models as Signs of argumentation and meta-understanding

The sign model has been tested due to the needs of being able to handle models at various levels due to the systems analysis approach. As I would like to be able to analyze various models as arguments and especially I would like to represent the process of argumentation in general as well as being able to distinguish between the three specific types of arguments: Abduction, deduction and induction.

In the following I will be referring to Toulmins model of argumentation as presented by Øhrstrøm (14). Due to this model we have two kinds of premises: Facts concerning the outside real world as well as system dependent rules defining how to conclude. In the diagram below (fig. 4) this principle is transformed into the formal ontology of the sign-model.

Fig. 4. The sign-model representing Toulmins (14) model of argumentation

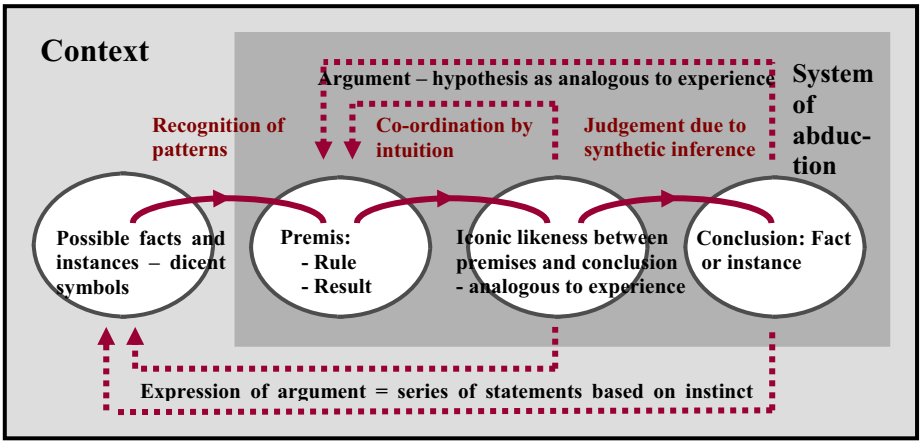


Due to Peirce an argument is a sign, where the interpretant represents its object as another sign by the law saying that conclusions based on this kind of premises are leading to the truth and the three types of arguments are characterizes by the way the argument is representing the type of insurance provided due to the triad: Instinct, experience or habit. Furthermore Andersen and Janzen point out how the basic triad

of icon-index-symbol is characterizing the relation between premises and conclusions regarding the arguments of abduction, deduction and induction.

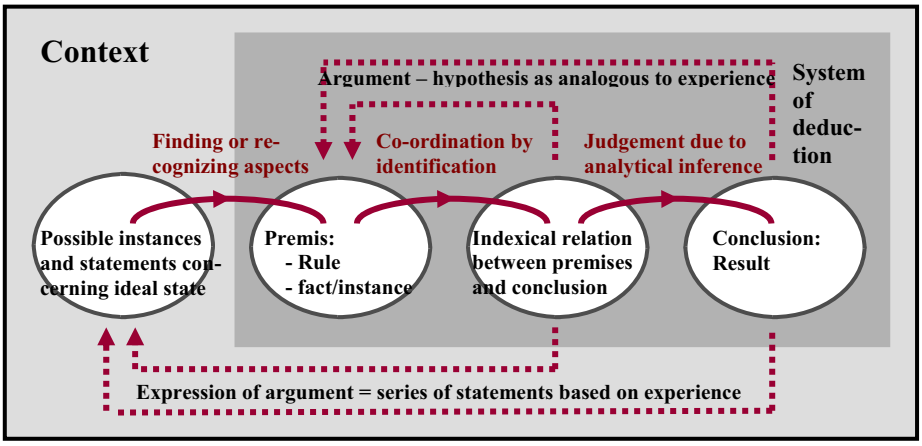
The abduction process generates the hypothesis characterized by initially imagining a possible fact by combining a rule and a result as illustrated below (fig.5)

Fig. 5. The sign-model representing the argument of abduction



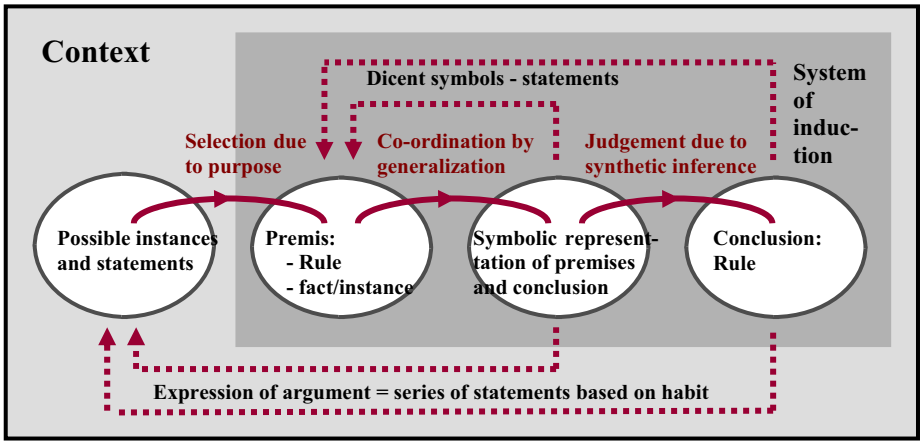
Pierce characterizes the deduction based reasoning by the process where two premises a rule and a fact defined by the rule. As illustrated below (fig. 6) the conclusion determines the result by using the rule on the fact.

Fig. 6. The sign-model representing the argument of deduction



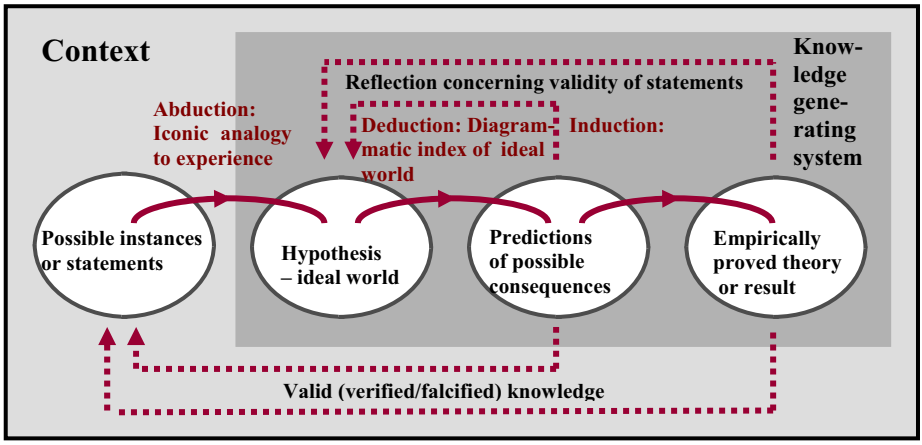
Pierce characterizes the deduction based reasoning by the process where two premises a rule and a fact defined by the rule. As illustrated above (fig. 6) the conclusion determines the result by using the rule on the fact. The process of inductive reasoning is characterized by having a fact and a result and on this basis reaching the conclusion of a rule as illustrated below (fig. 7)

Fig. 7. The sign-model representing the argument of induction



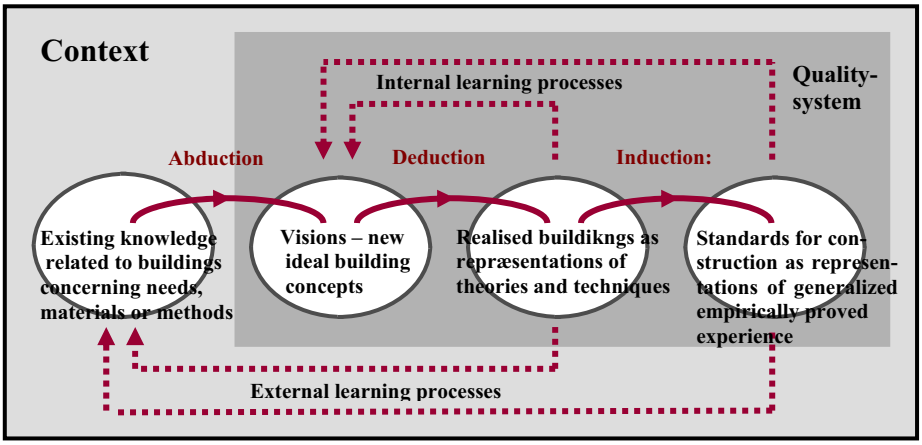
Due to the pragmatism of Peirce (8) the ideal scientific process combines the three types argumentation. This process is very similar to the hypothetic-deductive method suggested by Popper as argued by Osei-Bryson and Ngwenyama (7) who summarizes the process as: Empirical observation, hypothesis generation, design of experiments and finally empirically testing. Below (fig. 8) the scientific process due to Popper as well as Peirce is illustrated in the sign-model.

Fig. 8. The sign-model representing the identification, analysis and validation processes of research or daily life



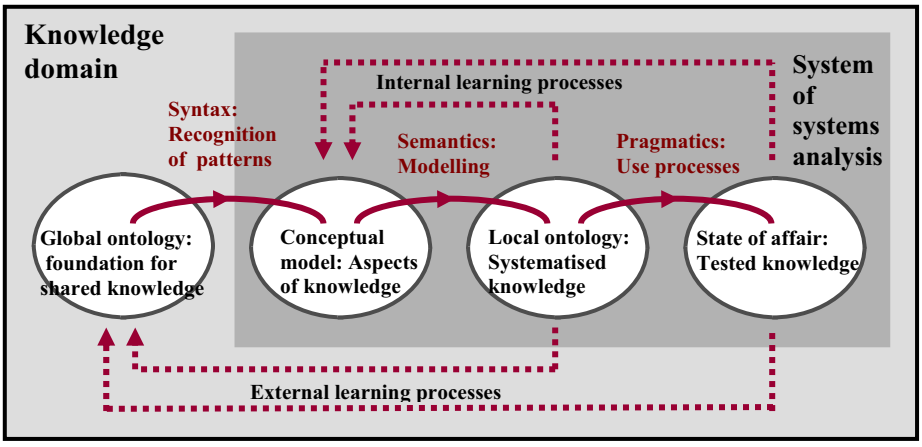
The processes of knowledge creation based on abduction, deduction and induction relates directly to various processes in the common practices. Below (fig. 9) is a little example from the built environment, where the feedback mechanisms represent the processes of internal and external organizational learning

Fig. 4. Representing knowledge related to ensuring quality of buildings



Dealing with the systems analysis of multipurpose multidimensional information systems the formalized models based on various aspects of syntactic, semantic and pragmatic aspects of the modeling process could be of interest due to the possibility of documenting effects relating to the iterative organizational learning processes. As illustrated below (fig. 10) also the concepts of local and global ontologies as specified by Yaser Bishr and Werner Kuhn (2) can be expressed by the model.

Fig. 10. Syntactic, semantic and pragmatic aspects of the systems analysis processes



In my Ph.D.-thesis several of those small experiments with the sign model are carried to ensure consistency dealing with models of various kinds and in various contexts. The understanding of modeling in general and the roles of the model as cognitive artifact in various design processes has been a central key to handling the research questions and methodologies of the thesis (10) behind this article. Due to this analysis it is argued that even if the multifunctional approach will emphasize problems concerning various representational views on buildings or geo-phenomena and despite the need for standardizing procedures and languages the multidimensional concepts supported by new communication technologies will provide a substantial framework for shared understandings.

4 Conclusions

In the geodata community as well as in the built environment metadata and meta-information as means of communicating content and usability of datasets and information setups has been a key matter for several years. The approach to this article has been the belief that a more abstract level for reflection and understanding of the various modeling processes is needed. Due to this demand a modeling tool based on the semiotics of Pierce has been introduced as a formal ontological framework capable of framing the various representational levels. On this basis the concept of signs of meta-understanding frames the general idea of abstract ontological concepts with the potential of mapping between various discourses and thereby create the basis for communication across disciplines and organizational borders. Due to this argumentation the understanding of the model as a cognitive artifact based on a representation of an argument that has to be understood as related to an actual context represents perfectly this idea of such signs of meta-understanding. In this article this general view on the fabric and dynamic of building models is presented as a formalized modeling tool and the capacity of this sign-model is illustrated due to the general process and aspects of argumentation and learning. Finally it is demonstrated how the syntactic, semantic and pragmatic aspects of the systems development process can be expressed in the model.

5 Further Research

According to Tom Gruber (5) an ontology is a specification of a conceptualization. Considering the goal of creating an ontological framework for handling multi-dimensional representations of building phenomena the presented aspects of the sign-model still remains on a very abstract conceptual level. So due to the need for specification further research has to be carried out to be able to concretize the various concepts of multidimensional representation and meta-communication in collaboration with the emerging digital practices of the built environment and the related information communities.

References

1. Andersen C. & Janzen C. Reklamekategorisering og kognition – et bidrag til perciansk reklamesemiotik. In Dinesen & Thellefsen, editors, *Semiotiske Undersøgelser*: 210-234, Hans Reitzels Forlag, København, 2004.
2. Bishr Y. & Kuhn, W. Ontology-based modelling of geographic information. In *Proceedings to 3rd AGILE Conference on Geographic Information Science*: 24-27. Helsinki, 2000.
3. Eco, U. *Kant og Næbdyret*, Forlaget Forum, København, 2000.
4. Jørgensen, K.G. *Semiotik – en introduktion*. Serien Gyldendal Filosofi, Nordisk Forlag, København, 1993.
5. Gruber, T. *What is an ontology*. www.ksl.stanford.edu/kst/what-is-an-ontology.html, 1993
6. Luhmann, N. *Sociale systemer*. Erik Reitzels Forlag, København, 2000
7. Osei-Bryson K.-M. & Ngwenyama, O.K. Peirce, Popper and Data Mining. In MIS *Quarterly Vol. 28 No. 1/March 2004*:106-42
8. Peirce, C.S. *Semiotik og pragmatisme*. Moderne Tænkere, Gyldendals Forlag, 1994.
9. Peuqeut, D.J. *Representations of Space and Time*. The Guilford Press, 2002
10. Raper, J. Geographical Information Science
11. Schrøder, L. *Tegn, fortælling og metaforståelse – et perspektiv på informationsdesign og bygningsdata*, Ph.D.-thesis, Aalborg University, 2005.
12. Stjernfelt, F. Betydning og transformation. In Bundgård, P.,Egholm, J. & Skov, M., editors, Kognitiv Semiotik: 91-116. P. Haase & Søns Forlag, København, 2003.
13. Worboys, M.F. *GIS - a computing perspective*. Taylor and Francis, London,1995
14. Øhrstrøm, P. *Logisk Set*. Forlaget Systime, Aarhus, 1998.