Philosophical background-assumptions in digitized knowledge representation systems

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1. Introduction

Along with the new prospects in the field of dissemination and management of knowledge and information that resulted from the rapid progress in computer sciences, many issues concerning the organization and classification of digitized knowledge and information appeared. The increasing accumulation of classification systems led computer scientists to

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the realization of the importance of conceptual modeling, which aims at expressing the meaning of terms and concepts used by domain experts to discuss the problem and to find the correct relationships between concepts. The realization of this fact is however not enough to resolve the problems caused by the lack of concrete and consistent classification systems which enable the modeling decisions to be made.

The practical problems of data integration indicated the need for "declarative representations" which "should have as much generality as possible to ensure reusability but would at the same time correspond to the things and processes they are supposed to represent"[1]. In other words, information scientists needed to face the problems related to the interoperability between different systems of organizing the information and the possibility of their expansion into other domains of application, which presupposes a common understanding of the notions used for the classification. As a result, they inevitably started to ask questions about the validity of their representations and their correspondence to things they represent, thus entering the field of philosophical reflection.

Within the domain of computer sciences, ontologies are developed in order "to reduce or eliminate conceptual and terminological confusion and come to a *shared understanding*"[2], an understanding which could function as a unifying framework for different viewpoints and serve as the basis for "communication between people with different needs and viewpoints arising from their particular contexts"[3]. However, the initial project of building ontologies seems to have remained unrealized since different groups of conceptual modellers and ontology engineers use different jargon in order to describe a certain subject matter. It could thus be argued that the development of ontologies has not only failed to solve the problem but –to some extent– it has duplicated it.

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[1] Smith B., & Welty C., "Ontology: Towards a new synthesis", in: *Proceedings of the International Conference on Formal Ontology in Information Systems*, ACM Press, New York 2001, p. 4.

[2] Uschold M., & Grunninger M., "Ontologies: Principles, methods and applications", *Knowledge Engineering Review*, 11: 2, 1996, p. 94.

[3] Uschold M., & Grunninger M., "Ontologies: Principles, methods and applications", *Knowledge Engineering Review*, 11: 2, 1996, p. 94.

However, the unsuccessful attempts at building a knowledge representation system that would allow access, compatibility and comparison across heterogeneous information systems should not discourage us from the effort to build an ontology which will meet the above demands. Doerr and Iorizzo argue, in contrast to traditional counter-arguments, that "a global knowledge network"[4] is feasible, as long as current research in this area is exempt from the preconceptions guiding it. Similarly, Henderson-Sellers, Gonzalez-Perez and Walkerden state that "every information systems researcher and developer" tacitly adopts philosophical stances, which, if explained and articulated, could lead researchers and developers "to make better decisions about modeling"[5]. Thus, in order to investigate the feasibility of developing fundamental principles and methods of a unified knowledge representation system we need a philosophical critique of the confusions that prevail in the field of building ontologies.

2. Confusions in ontology

In our view, many of the difficulties emerging in the field of knowledge representation might be resolved if we shed light on the implicit philosophical assumptions that are obscured within the process of building ontologies. Thus we intend to focus on the epistemological questions emerging in the field of ontology-building in computer sciences and to elaborate on the methodological principles and the philosophical-epistemological presuppositions of such a project. However, the first step towards this is to clarify some confusion, which seems to hamper the building of a global knowledge representation system.

There have hitherto been several attempts to define ontology in computer sciences. In 1980 McCarthy had already noticed that

[4] Doerr M., & Iorizzo D., "The dream of a global knowledge network – A new approach", *Journal on Computing and Cultural Heritage*, 1: 1, 2008, p. 1.

[5] Henderson-Sellers B., Gonzalez-Perez C., & Walkerden G., "An application of philosophy in software modelling and future information systems development", in: Xavier F., & Soffer P., (eds.) *Advanced Information Systems Engineering Workshop: Proceedings*, Springer, Berlin/ Heidelberg 2013, p. 330.

the modelers of intelligent-systems should first of all build an ontology of our world by listing everything that exists.[6] In 1984 John Sowa recognized the need for cooperation between philosophy and computer sciences in relation to the representation of knowledge on the basis of an ontology as a listing of everything which constitutes the world.[7] Shortly thereafter Genesereth and Nilsson offered a definition of a conceptualization which proved crucial in defining ontology in computer sciences.[8] Consequently, Gruber defined ontology as "an explicit specification of a conceptualization"[9], a definition which evolved into a benchmark to locate and define ontology in the field of computer sciences.[10] However, Gruber's definition proved too broad and therefore prone to different interpretations. This prompted Guarino in 1998 to reconsider the notion of conceptualization and to analyze the parameters involved in the identification of ontology. Guarino thus gave a definition of ontology that has determined the debate on this issue ever since.[11]

Despite the great contribution of the above-mentioned efforts in establishing and developing ontology in computer sciences, they do not seem to meet all the requirements of ontology building. Rather, the advocates of ontology seem to have become entangled in confusions derived, in our opinion, from the background-assumptions that they have tacitly adopted. Our aim is thus to demonstrate the confusions, in order to bring to light some of the misleading assumptions, which dispirit researchers

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[6] See McCarthy J., "Circumscription: A form of non-monotonic reasoning", *Artificial Intelligence,* 13: 1-2, 1980, pp. 27-39.

[7] See Sowa J., *Conceptual Structures: Information Processing in Mind and Machine*, Addison-Wesley, 1984.

[8] See Genesereth M. R., & Nilsson N. J., *Logical Foundation of Artificial Intelligence*, Morgan Kaufmann, 1987.

[9] Gruber T. R., "Toward principles for the design of ontologies used for knowledge sharing", *International Journal of Human Computer Studies* 43, 1995, p. 908.

[10] Similar definitions of ontology to Gruber's are mentioned by Guarino, Oberle and Staab in: Guarino N., Oberle D., & Staab St., "What is an ontology?", in: Staab S., & Studer R., (eds.), *Handbook on Ontologies,* Springer, Berlin/Heidelberg 2009, pp. 1-17.

[11] See Guarino N., "Formal ontology and information systems", in: Guarino N., (ed.) *Formal Ontology in Information Systems: Proceedings of FOIS' 98*, IOS Press, Amsterdam 1998, pp. 3-15.

from considering the goal of a global knowledge network as feasible.

3. The confusion concerning the functions

The first confusion emerging in the field of present research in ontology building has to do with the functions that conceptual modellers and ontology engineers ascribe to the ontology. In line with the background assumptions that they seem to presuppose, ontology is regarded as a knowledge representation system which has the following objectives: i) To maintain the cognitive content of the material represented, ii) to reduce, as far as possible, the risk of misinterpretation of the content transmitted, iii) to allow, via a shared conceptualization, communication between the members involved in the digital world. If we look closer at the functions that ontology is supposed to perform, we notice that there is a kind of contradiction between them.

3.1. *The first function*

In agreement with the first function, a knowledge representation system should represent knowledge in the most integrated way. In this context, knowledge is treated as a descriptive source which provides "factual information on how certain things are. A source of knowledge may be descriptive without being truthful, reliable, authoritative, etc."[12]. Thus, not only scientific conceptions and theories but also empirical facts or "philosophical or commonsense beliefs"[13] are included here. This kind of knowledge does "not often allow for sound and complete reasoning"[14]. In other words, we can not qualify this kind of knowledge simply as true or false. Knowledge as a descriptive

[12] Garbacz P., & Trypuz R., "A metaontology for applied ontology", *Applied Ontology*, 8: 1, 2013, pp. 7-8.

[13] Garbacz P., & Trypuz R., "A metaontology for applied ontology", *Applied Ontology*, 8: 1, 2013, p. 8.

[14] Garbacz P., & Trypuz R., "A metaontology for applied ontology", *Applied Ontology*, 8: 1, 2013, p. 14.

source has a content that becomes meaningful in certain contexts and also has reference to the real world.

3.2. *The second function*

The second function ascribed to ontologies is the transmission of information to the users in such a way as to avoid its distortion –as far as possible – because of the users' subjective interpretations. The demand for intersubjectivity and commitment to a specific viewpoint on the representation of the world frequently leads ontology designers to seek normative criteria to deal with the material that they have at their disposal. As, however, our experience has so far revealed, searching for normative criteria leads to two opposite results: either in treating the knowledge representation systems as "computable functions"[15], which are "finite"[16], or to the partial release from the request for compatibility between different knowledge representation systems.

Concerning the first alternative (treating ontology as a finite function), the theoretical presupposed stance is that the criterion for constructing ontologies is its effectiveness as a function of the time required for a certain search and the successful completion of this search. Preconditions for this kind of function are the precise identification of the required steps, the reproducibility of these steps and the soundness of the resulting outcomes. In other words, for the implementation of this kind of function, strictness and precision that can only be found in the syntax are required. This kind of function is, therefore, restricted in concrete forms of application and cannot satisfy all the requirements resulting from the process of the representation of knowledge, which ontology is called to reflect with the aid of semantics.

The second alternative (ontology as a partial release from the demand for compatibility) often results in the building of local ontologies based on arbitrary principles, which cannot satisfy the demand for the shared understanding of a conceptualization.

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[15] Denning P. J., & Bell T., "The information paradox", *American Scientist*, 100: 6, 2012, p. 474.

[16] Denning P. J., & Bell T., "The information paradox", *American Scientist*, 100: 6, 2012, p. 474.

3.3. *The third function*

The third function that the above-mentioned approaches to ontology seem to presuppose is the communication function between those participating in acts related to the exchange of information in the digital world (users, machines, different systems of presenting knowledge, different domains). The crucial point in the framework of this function is the kind of communication we establish in order to achieve the goal of a shared conceptualization and understanding. If we consider communication only as a mechanical response to a query, we regard communication as a one-dimensional act which cannot achieve the goal of building a common language between different viewpoints, as the experiment of Searle's Chinese room argument has very clearly demonstrated.[17]

Achieving this goal demands interactive communication, through which we can integrate the query raised, in order to understand it properly. This requirement demands reference to the meaning of a query and its relationship with the physical object, which very often –as we have mentioned- does not allow for exhaustive reasoning. Interactive communication leads us thus to the second confusion that dominates the field of ontology building: the domain-confusion.

4. Domain confusion

Concerning the significance of domain in ontology Garbacz and Trypuz observe: "The description of the domain of an applied ontology corresponds, *mutatis mutandis*, to the philosophical characterization of the concept of being"[18].The domain seems to be the only *object* of reference of the ontologies in computer sciences. But what are the implications of this statement? Garbacz and Trypuz continue:

[17] See Searle J. R., "Minds, brains, and programs", *Behavioral and Brain Sciences*, 3: 3, 1980, pp. 417-457.

[18] Garbacz P., & Trypuz R., "A metaontology for applied ontology", *Applied Ontology*, 8: 1, 2013, p. 9.

In knowledge representation the range of entities which a given applied ontology commits to depends on a particular engineering problem that this ontology is to solve. Thus, its domain may be compared to the concept of being *modulo* this problem, i.e. it will contain those entities that in the view of the developer(s) of this ontology we need to posit in order to solve this problem.[19]

This approach to domain manages to formulate, in a very comprehensive way, a common belief among ontology designers with respect to the domain and its role in ontology. But it also reveals a contradiction that, from our point of view, lies in the basis of many ontologies that have been developed to date. The contradiction lies in the fact that, while domain in knowledge representation systems seems to have the role of "being" in philosophy, the kind of entities that the ontology in computer sciences contains depends on the "view of the designer of this ontology". Thus, domain itself, which is the "physical object" (i.e. being) of the ontologies seems to depend on a subjective factor, which calls into question the intersubjectivity that is one of the main goals of building ontologies.

Thus the attempt to exclude the arbitrariness caused by the intervention of subjectivity and to achieve a relatively "objective ground" for building ontologies – a goal that led, for example, Gangemi, Catenacci, Ciaramita and Lehmann to consider the capacities and knowledge of rational agents as a "black-box"[20] – undermines itself, since the domain and the "entities" that it contains are dependent on the view of the designer. This approach to domain contradicts the initial objective of ontology building, as it creates the conditions for the existence of different "points of view" and thus of many ontologies.

This view of domain is based on a type of relationship between reality, knowledge and knowledge representation systems, wherein the role of the former i.e reality, has been neutralized. Thus, the "objects" of reference in knowledge

[19] Garbacz P., & Trypuz R., "A metaontology for applied ontology", *Applied Ontology*, 8: 1, 2013, p. 9.

[20] Gangemi A., Catenacci C., Ciaramita M., & Lehmann J., "Modelling ontology evaluation and validation", in: Sure Y., Domingue J., (eds.) *The Semantic Web: Research and Applications*, Springer, Berlin/Heidelberg 2006, p. 145.

representation systems are not the physical objects and their relationships but rather the sphere of knowledge and information, which is independent of physical objects.

It seems therefore that all the efforts of computer scientists and ontology designers to represent knowledge stumbles upon a problem that philosophy has faced many times so far: the problem of the reference of knowledge. As shown by the long philosophical tradition, the only way to avoid psychologism and relativism in representing knowledge is by reference to a criterion that is external to the subject and its products. But the only way to detect such a criterion while avoiding the pitfall of metaphysics is by reference to the empirical world, through which we can verify or falsify our claims, beliefs, knowledge etc. Thus, in the 20th century scientists and philosophers have, to a great degree, abandoned the question of the origin of knowledge and focused on the empirical foundations of scientific knowledge. This shift has thus initiated a debate, which, despite its shortcomings, has prompted the development of sciences and its critical evaluation. The question which arises in this context is if such a practice could be feasible and effective for building ontologies in computer sciences.

From our point of view the reference to the empirical world is not only feasible but is the only way to build an ontology which can achieve the goals of interdisciplinarity and intersubjectivity of knowledge representation. However, the reference to an external factor presupposes another form of relationship between ontology and its entities i.e. the domain through which it would be possible to reveal the background assumptions, which are tacitly presupposed, not only by the designers of knowledge representation systems, but also by experts in the knowledge represented.

The purpose of the ontological commitment is not, therefore, to commit ourselves to the ontology designer's view from the beginning but to question it. This indicates another form of relationship between knowledge representation systems, the knowledge represented and its connection to reality, a "dialectical relationship" that may lead us to forms of knowledge representation that could demonstrate the properties of an object and its behavior independently of the subject and its theoretical stances. In line with the dialectical relationship, ontology is the result of a dynamic process which takes into account the real object that is represented and questions the viewpoint of the specific sciences, from which we derive the knowledge to be represented. The only means that we have at our disposal to deal with our material is the possibility of verification or falsification through reference to the behavior of the related physical object[21]. As long as we do not abandon the goal of a relatively objective foundation of knowledge representation systems, we can detect, through a dialectical relationship between the ontology and its objects, ways of representing knowledge, which demonstrate certain aspects of the objects and their behavior. These ways, thus, could be used as "recipes of knowledge" that will no longer reveal the scientists' and conceptual modelers' bias but aspects and behaviors of the physical objects of our experience and the systematic ways in which they appear as facts under different scientific viewpoints.

5. Conclusion

In our view, the clarification of the philosophical-epistemological assumptions that are relevant to problems concerning knowledge representation systems will enable us to build a new method of ontology engineering based on the observation of the material and its use both by the experts and by users from different backgrounds. Through the observation of the material we can detect how a certain concept, as the mediation between reality and perception, is used in different environments, a fact that enables us to derive, through the comparison of different kinds of perception, the "essential" properties of the concepts regardless of their context. The necessary condition for this procedure is the dialectical relationship that manifests itself as a bidirectional movement that runs through the top-level concepts down to the material and vice-versa, within which all components (the experts, the top-level concepts, the context and the material) are equally decisive for the representation of knowledge in any form.

[21] The practice of falsification was firstly introduced by Popper in: Popper K. R., *Logik der Forschung: Zur Erkenntnistheorie der modernen Naturwissenschaft*, J. Springer, Wien 1935.

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Abstract:

In the field of knowledge representation that resulted from the rapid progress in computer sciences during the last decades many issues concerning the organization and classification of digitized knowledge and information appeared. Despite efforts so far to establish and develop ontology in computer sciences, they do not seem to meet the requirement of a shared framework for different viewpoints. This paper offers a clarification of the confusions arising from philosophical and epistemological background assumptions which prevail in the field of ontology building and describes the main methodological outlines which could enable conceptual modelers and ontology engineers to achieve the goal of a shared understanding with the aid of philosophy.

Keywords: Ontology, conceptual modeling, engineering, philosophy, knowledge representation.