Epistemological Questions in Knowledge Representation Systems

A Position Statement

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Introduction

In a world of increasing production of knowledge and information, the efforts of representing the existing scientific knowledge in a digitized form are continuously growing. At the same time, the rapid development of computer science creates the preconditions for making a global network of interconnected knowledge feasible – as long as we do not demand global consistency. However, this goal has proven difficult since the detachment of knowledge and information from the subjects possessing them and the transcription into positive and discrete propositions, as required by IT (information technology) systems, require a deep and thorough understanding of this knowledge and how to adequately deal with it. In particular, differently encoded units of information about the same topic exhibit much less common meaning to automated algorithms than human comprehension of the same information would let us expect, and hence limit the degree such systems can detect related facts across different sources. This has become a vital issue in a world in which the sheer amount of information available exceeds any human capability of searching manually through it, even in very limited domains.

This realization has led computer scientists in the mid-1990s to recognize the importance of conceptual modeling by so-called formal ontologies, which aim at expressing the meaning of concepts used by domain experts to structure their data by commonly accepted unambiguous concepts and relationships. Systems that employ formal ontologies directly as means to structure data are considered “knowledge bases” in the narrower sense. Despite the numerous efforts however to construct shared, unambiguous conceptual models that experts can use to share their knowledge in the form of structured data beyond a particular community and discourse, the conceptual modelers and ontology engineers, coming from mathematically oriented engineering disciplines, very often have difficulties to recognize the need and to find the theoretical principles and methods they should follow in order to manage scientific knowledge consistently with its intrinsic epistemology so that the interoperability between different systems of representing knowledge, disciplinary views and domains could become feasible. This shortcoming has led after two decades to the proliferation of “new ontologies” with limited application in specific fields, often outcome of ad-hoc and intuitive design processes or community votes put into a logical-mathematical framework, which rather seems to hinder the quest for interoperability and compatibility between different systems of representing knowledge than to facilitate it.

This unexpected result leads to the realization that every system of knowledge representation[1] tacitly presupposes epistemological and philosophical assumptions, which are not only of logical and

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[1] To be more precise, by *knowledge representation systems* (KR systems) in the widest sense we mean any mechanical database system that stores and manages access to and deductions from *data* structured in a way that *is or could be* transformed into sets of *logical propositions with predicate symbols* taken from some vocabulary of terms. We do not comprise in this definition natural language texts, but for instance any collection of scientific data in whatever encoding. By *sciences* we mean any natural science, but also any science from the field of humanities that takes physical evidence as

algorithmic nature but should be made explicit in order to help modelers of knowledge representation systems develop adequate formalizations in agreement with the system users' own discourse. What further increases the difficulty is the fact that the users themselves are not trained to recognize their own epistemology, and therefore often present inconsistent interpretations of their own methods to system developers. We therefore believe that the attempts to elaborate the philosophical assumptions presupposed in knowledge representation systems not only will result in resolving much of the incompatibilities in digital systems of KR, but they will also contribute to make rich interdisciplinary knowledge exchange feasible.

Thus, our initial thought for organizing the workshop concerning the epistemological questions in knowledge representation systems that took place on September 25th in Heraklion Crete, at Centre for Cultural Informatics of the Institute of Computer Science of Foundation for Research and Technology-Hellas. This was to set questions and to search for answers in the field of philosophy and computer sciences in order to strengthen our endeavor to facilitate the interdisciplinary and knowledge exchange between different sciences in a digitized world.

Conclusions

After an extensive discussion concerning the epistemological questions emerging in computer sciences we reached the following conclusions that will serve as starting points for further discussion and investigation:

a) The collaboration between philosophy and computer sciences is considered not only desirable but also necessary in order to seek answers to questions raised in the methods of modeling and construction of KR systems for sciences, ultimately with the aim to increase the amount, scope and quality of knowledge mediated and shared via mechanical information systems.

b) We do not intend to adopt a particular philosophical stance as "correct" for conceptual modeling and ontology engineering, but to investigate different theoretical positions which could be synthesized and proven to be effective for our investigation. These theoretical positions should thus satisfy the following criteria:

   - They should not contradict each other.
   - They should be applicable and intelligible within the related domain of their reference.
   - They should be effective in the sense that they help us to conclude, describe and predict the behaviors and substantive properties of the objects of the scientific knowledge concerning us.
   - They should also consistently explain scientific knowledge revisions and the relationships between previous states of knowing and their justifications.

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argument, such as manuscripts, archaeological findings, observation of human behavior and others. We exclude however mathematics, because its field of reference does not depend on physical evidence.

- It should, in principle, be possible to empirically test these theoretical stances by referencing the observable scientific facts and behaviours that we want to represent in conjunction with the concepts of progress of knowledge that the scientists employ.
- Empirical evidence should be an argument for or against a theoretical stance. Theoretical positions that have no bearing on anything that can be experienced are not of our concern.

c) Knowledge and information should be seen within the framework of an intersubjective acceptable way of communication within a shared reality. This communication must not be seen as limited to a community of "scientists", but bound to their acceptable forms of reasoning. In this framework, the process of constructing the meaning and its reference is deemed crucial for knowledge and information management.

d) Since the management of knowledge and information is seen within a framework of interactive (dialectical) relationship between the scientists, their domain and its reference, the observation of these interactions and behaviours are crucial for the construction of the network of the concepts of a knowledge representation system.

e) Even though knowledge representation systems need to be based on a formal ontology, it is almost evident that "closed" classification systems based on strict and exhaustive definitions of classification categories will not be enough to meet the needs of the dynamic evolution of knowledge and information in its relation to the domain of reference.

f) The formulation of logical constraints does not appear sufficient for the adequate representation and integration of knowledge and information of scientific content in knowledge representation systems.

g) We hold that an ontology for scientific knowledge depends on the questions to be answered (compare for instance thermodynamics with molecular dynamics). The way in which the questions, the form of discourse and referred reality determine the ontology, and the degree to which different ontologies should, due to these parameters, contain comparable concepts that allow for their integration, is a subject of this investigation.

h) Since scientific data are supposed to be "true" and about "a shared reality", necessarily adequate conceptions of truth and reality compatible with the effective concepts of verification and knowledge revision must be in the core of our investigation.

i) We further hold that the elaboration of the relationships between subjects, knowledge, its representation and its relation to the reality represented could lead us to the construction of one or more ontologies in computer sciences which could meet the requirements for intersubjectivity and interdisciplinarity of sciences.

j) Since facts are commonly accepted and exchanged between disciplines (such as the Plague of Athens), we maintain that any obstacle to create an effective, common, interdisciplinary ontology has nothing to do with disciplinary differences or subjective choices. We further expect that the ultimately incomparable ontologies in sciences should be few, and that they should describe justified views of one common reality.

We consider the above mentioned points of agreement to be the first step towards a more substantive collaboration between the computer science and philosophy, which could contribute to a creative approach and resolution of issues emerging in the field of knowledge representation.

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