Conceptions and Context as a Fundament for the Representation of Knowledge Artifacts

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ABSTRACT

It is a well-known fact that knowledge is often not objective and not context-independent. However, in many application systems knowledge is treated as objective and independent. In this paper it is argued that subject and context dependencies of knowledge need to be reflected in knowledge representation. Bernd Mahr's Model of Conception offers a fundament for new knowledge representation technologies which takes these properties of knowledge into account. Nevertheless, it is still possible to represent objectivity and context-independence in the model.

Davis, Shrobe and Szolovits [2] outlined five roles of knowledge representations. In this paper we will examine Bernd Mahr's Model of Conception in these five roles and argue for its usefulness in modelling information systems.

Keywords: subject-dependency, objectivity, context, conception, knowledge representation, modelling

1. INTRODUCTION

The need for interoperability and semantic integration in information systems shows that subject- and context-dependent actions and processing are almost everywhere present.

Bernd Mahr argues with the Model of Conception, that everything which is conceived of by some subject is conceived of as something influenced by a context. The context is not only influencing the conception, it even is the only source of meaning for the conceived object.

Context is not naturally existing but originates from subject's conceptions and actions of interpretation. It supports the subject in recognizing relevant information and using it in the process of reasoning.

In the following sections, we will first discuss how the notion of context was analyzed and used in literature. Then we introduce Bernd Mahr's Model of Conception, along with its views on subject– and context-dependency. Later we explain the five roles of knowledge representation according to Davis, Shrobe and

Szolovits [2] and examine the Model of Conception in these roles. The envisaged scope of knowledge representation based on the Model of Conception includes agent systems, telecommunication, distributed AI-systems, context-aware systems, ambient intelligence systems and others. It also could be a step into the direction of generality in AI.

2. CONTEXT IN LITERATURE

There is lots of work related to context, e.g. in the fields of context-aware computing, ubiquitous computing, linguistics, artificial intelligence and many others, but there is only a small line of work, which particularly focuses on the concept of context itself.

The need for representing context was probably first stated by John McCarthy in [13]. He argued, that in order to reach the goal of generality in AI, the notion of context needs to be formalized. Then, in [14] and [15] he made a first approach, by adding abstract contexts to logical formulas.

Following the ideas of McCarthy, Ramanathan V. Guha developed a logic, based on first order predicate calculus, which handles contexts [5].

Based on the work of McCarthy and Guha, Doug Lenat built his common sense knowledge base *CYC* (see [1], [10]). The knowledge base is build as a lattice of contexts. Each context then consists of a set of assumptions and a set of content assertions, which hold under the assumptions.

Dourish analyzed in [4] how the notion of context is used in ubiquitous computing and on which principles it is based. He describes these principles as a *representational model* and argues for a new set of principles, which he calls an *interactional model*. One important change he introduces is that context is dynamic and not static.

Kokinov in [8] analyzed the notion of context from a cognitive point of view and found several properties that characterize the term. He also built a cognitive architecture called *DUAL*, which offers an implicit model of context. We'll come back to this model later.

Anind K. Dey [3] even offers a definition for context:

> Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.

The definition focuses on interactions between users and applications, but nevertheless, it captures a point that was also seen by Kokinov: Context is any information that is considered *relevant*.

Based on these insights into context, we provide a more detailed analysis of context-dependency in [6].

3. BERND MAHR'S MODEL OF CONCEPTION

The term *conception* is used in a wide variety: We say that *something is conceived of by somebody* and mean situations where somebody perceives something with his senses in a certain way; where somebody thinks of something somehow; where somebody wishes something to be; or where somebody understands that certain things are related to each other in a certain way.

Based on his work on "Object and Context"[1] [11] and on following studies on the notion of *context* Bernd Mahr developed his *Model of Conception*, which was published in [12]. It models conception by relating the term to the three other terms *subject*, *object*, *context*, and it derives from it the notion of the *content* of a conception.

None of these terms can be seen as being "more basic" than the others and each of the terms can only be understood in relation to the others. Thus, the Model of Conception can also be seen as a model of "object", of "context", or of "content".

Following the model, a subject conceives of an object in some context. The context is a complex which consists of relationships into which the conceived object is embedded. These relationships determine the content of the conception.

Clauses of the Model of Conception

Bernd Mahr's Model of Conception is given by thirteen clauses in natural language:

Entity

1. An entity is something that is. Anything that is, is an entity.

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[1] translated from German "Gegenstand und Kontext"

2. An entity is the content of some conception.

3. Any two entities are different.

Both, the concepts of conception and content are explained in later clauses. However, they are entities themselves and so this clause results in a circular relation, which states that both, conceptions and contents are themselves a content of some conception.

Relationship

4. A relationship is an entity by which entities are related.

5. An entity belongs to a relationship, if it is one of the entities which are related by this relationship.

Complex

6. A complex is an entity by which entities belong to relationships.

7. A relationship belongs to a complex, if the entities which belong to this relationship belong to this relationship by this complex.

8. An entity belongs to a complex, if it belongs to a relationship which belongs to this comxplex.

Conception

As the name states it, conceptions are central in the model of conception. They are, together with the content of a conception, described by the following two clauses:

9. A conception is a relationship by which an entity, identifiable as the subject of this conception, an entity, identifiable as the object (or subject matter) of this conception, and a complex, identifiable as the context of this conception, are related.

10. The content of a conception is a complex, to which exactly those relationships belong, which belong to the context of this conception, and to which the subject matter of this conception belongs.

Situation

11. A situation is a complex in which all entities which belong to this complex are conceptions.

Universe

12. A universe is a complex to which with every entity which belongs to it, also belongs a conception, whose content is this entity.

13. A universe is called reflexive, if it belongs to itself.

Example

The following example demonstrates an application of the Model of Conception:

A man and a woman are sitting in a restaurant and the man gives his credit card to the waiter to pay.

The whole event can be described as a *situation*, a *complex* which consists of many *conceptions*. In this case, there are conceptions where either the man, the woman, or the waiter are the *subject* of the conception.

One of these conceptions would describe that the man uses his credit card to pay. He would be the *subject* and the credit card would be the *object* of this particular conception.

The *context* of the conception would contain *relationships* that describe information about credit cards in general, about the role of a waiter in a restaurant, and that the waiter needs the card to process the payment.

The *content* of this conception would consist of all information in the context that relates to the credit card. This content would describe the actual meaning of the credit card in this particular context.

Viewing this situation as an entity in the Model of Conception shows how complex this seemingly simple example is.

Subjectivity vs Objectivity

By introducing the term "subject", the model, among other things, allows explicit description of communication situations between persons, between machines and between a person and a machine. Furthermore, subjects are not restricted to persons and computers. Every entity that can have a conception of something can be seen as a subject. Thus, also a whole nation, a book on art, or a scientific community could be the subject of a conception.

The first clause of the Model of Conception states that "Anything that is, is an entity" and thus, the model simply takes *everything* into account. One may assume, that therefore the Model of Conception itself is an ontology of everything, but in fact, it takes an opposite role.

Entities in ontologies are supposed to be objective in the sense that they are independent of a conceiving mind. By the second clause any entity is the content of some conception and therefore depending on a subject and a context. Consequently, the model itself and each ontology are entities and as such subject-dependent. According to [17] "the ontological status of objectivity can only be given within an ontology".

Because of the subject-dependency of Bernd Mahr's Model of Conception, it was originally coined *A* Model of Conception and not *The* Model of Conception. In this paper we often use the article *the*, referring to the model made by Bernd Mahr. We do not intend to see it as the only possible model. It is in the very nature of the model, that there are other models in other conceptions.

Context-Dependency

According to the second clause of the Model of Conception, every entity is the content of some conception. Therefore every entity must be a complex, which consists of relationships from the context of the conception. The content of the conception is the whole meaning of the entity and it is completely derived from the context of the conception. In other words, the content is a part of the context of a conception.

Following this idea, an entity alone has no meaning. The whole meaning of an entity is given by its relationships to other entities.

Consistency of the Model of Conception

For using the Model of Conception in calculations, it needs to be formalized somehow. This seems to be problematic because of the circular nature of the model: A conception is a relationship and thus an entity. Each entity is the content of some conception and thus each conception is the content of a conception.

In [17] Tina Wieczorek formalized the model by writing the logical reading of its clauses in first order logic notation, using appropriate function and predicate symbols. She gave two axiom systems for universes, and constructed for each of these systems a Tarski-style model.

Her model constructions do not only prove consistency of the Model of Conception, also in the case of reflexive universes, but they also show that the conventional set-theoretic universe and the ϵ-theoretical universe of ϵ-sets are both universes in the sense of the Model of Conception. In ϵ-theory it is possible to consistently represent reflexive and circular structures up to self-reference.

4. FIVE ROLES OF KNOWLEDGE REPRESENTATION

In [2] it is argued, that knowledge representation is best described in five roles: It states that a knowledge representation is

a surrogate Every reasoning process takes place in the mind of some reasoning entity. Thus, there must be a representation of everything the entity is reasoning about in its mind.

a set of ontological commitments The ontological commitments are "a strong pair of glasses that determine what we can see, bringing some part of the world into sharp focus at the expense of blurring other parts." [2]

a fragmentary theory of intelligent reasoning This theory usually describes three components of reasoning: a fundamental conception of intelligent inference, a set of inferences that the representation sanctions, and a set of inferences that the representation recommends.

a medium for efficient computation The knowledge representation must not only represent knowledge, but it must also allow for efficient usage of the knowledge in inference processes.

a medium of human expression A knowledge representation should allow humans to describe their knowledge in a natural way.

In [16] John F. Sowa argues that these five roles "can be used as a framework for discussing the issues of knowledge representation". Following this idea, we will examine the Model of Conception with respect to the five roles, to motivate its potential usefulness as a fundament for knowledge representation.

The Model of Conception as a Surrogate

The Model of Conception was largely inspired by cognitive science and thus, is based on the idea, that everything in our mind is a conceived thing. We can only think, talk and act on things which we have conceived before. The idea of conceptions is expressed by the sentence "There is nothing for us, which is not through us.[2]"

According to [2] everything that an intelligent entity is reasoning about is an internal representation of a real thing in the external world. As a result from this thought, the authors come up with two questions about surrogates: "What is it a surrogate for?" and "How close is the surrogate to the real thing?".

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[2]This statement was made by the German philosopher Günther Figal.

The Model of Conception does not deal explicitly with the external world. It does not represent the "real thing" directly, but the conception of a thing, which is already internal. Still, such a conception is a real thing too, and so we have two levels of surrogates here: first, the conception and the content as a surrogate for the real thing and second, the Model of Conception as a surrogate for the conception.

For the first level, in the example given above, there is an entity which is a surrogate for the credit card and the content of the described conception is a surrogate for what the man considers relevant to the credit card in the context of a restaurant.

For the second level, the question "How close is the surrogate to the 'real' thing?" translates then to "How close is the Model of Conception to the 'real' conceptions?". Although the thirteen clauses of the model are carefully formulated, they are very abstract and thus, they leave room for interpretation. So the answer to this question depends on the way in which the Model of Conception is formalized.

Ontological Commitments in the Model of Conception

As we have argued before, the Model of Conception is not an ontology in the sense that it does not claim objectivity. Still, there is an ontological commitment to concepts like *entity*, *relationship*, *conception*, *subject*, and *context* and to the way they are related to each other. This kind of commitment is fairly minimal, like it is in the case of logic. Every model based on the Model of Conception would use these few concepts to represent others.

The amount of ontological commitment for a knowledge representation should depend on its purpose. For a tool that is specialized on a certain area the corresponding knowledge representation does only need to cover that area.

The Model of Conception was not designed for a specialized application, but for applications in many different fields. A human is not restricted to understand a limited set of concepts, and thus the Model of Conception should not be restricted in the same way. Every restriction in this sense would prevent realizing McCarthy's goal of generality in AI.

A Fragmentary Theory of Intelligent Reasoning based on the Model of Conception

The Model of Conception does not include a theory of reasoning and therefore it is no knowledge representation by itself. Nevertheless it can be seen as a fundament for a theory of reasoning and thus for a knowledge representation. Ideas for such a theory can

be found in the models of cognitive science. One concept that is particularly interesting is described by Kokinov in his *DUAL*-architecture [7]. The architecture is a net of DUAL-agents, called nodes. Kokinov introduces the notion of *activation* which is a property of a node and which practically denotes how relevant this node is in a particular situation.

Interpreted in the Model of Conception it means, that the object of a conception serves as a source node which has a constant level of activation. It spreads a percentage of its activation to the entities which are related to it. These entities again spread a part of their activation and so the activation propagates through relationships. All entities have a certain threshold and when their activation is below the threshold, they are inactive and will not spread any activation.

By the concept of activation the concept of *relevancy* is modeled, which was seen as a important part of context by Kokinov and Dey.

Efficient Computation in the Model of Conception

In the Model of Conception, calculations would manipulate conceptions and contexts. Doug Lenat describes context in [9] as follows:

> We understand the potential usefulness and power of contexts, of being in and reasoning within a context:
>
> - Enabling us to ignore 99.999% of our knowledge so we can focus on the task at hand
> - Enabling us to be terse and sloppy in our communications and yet expect our readers/listeners to understand our intent
> - Enabling us to accommodate apparently contradictory information, by partitioning it out to different contexts

The first item in his list explains, why computations on contexts would be efficient. Sorting out irrelevant information provides a means to reason about things as it reduces the amount of information to a proper size which can be handled.

In the given example, only relationships are considered relevant, which on the one hand are related to the credit card, and which on the other hand are part of the restaurant context.

The Model of Conception as a Medium of Human Expression

There is no formal language defined for the Model of Conception. However, as we mentioned before, it is inspired by cognitive science and therefore by the human mind. Thus, a language based on the Model of Conception would allow for a very natural way of expressing knowledge in terms of relationships and complexes.

5. CONCLUSION

We discovered that the Model of Conception by itself is no knowledge representation, but that it is possible to create one on its basis. A first step towards it is to formalize the Model of Conception, which we are currently working on. The next step would be to develop a theory of reasoning on top of the model. The theory should formally define the notion of relevance and thereby allow for efficient computation. Further, we need to define a formal language that allows for a natural way of expressing knowledge.

Our examination of Bernd Mahr's Model of Conception with respect to the five roles of knowledge representation argues that it can serve as a fundament for knowledge representation. The model introduces the two central concepts of subject– and context-dependency, which offer a new perspective into representing knowledge. The idea to include these concepts into the model is inspired by cognitive science, and its goal is to improve the way that computers handle knowledge artifacts and make it more similar to the way humans do.

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