Mapping the Multitude.
Categories in Representations

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Abstract. One of the main problems with artificial intelligence is the fact that the information which artificial intelligence is typically required to handle is heterogeneously structured. Ontologies are designed to mitigate this effect. From a philosophical perspective, we refer to an ontology when we have a systematic representation of principles whose various relations can adequately describe a subset of the world. The interrelation of these principles constitutes a real world scenario. Humans use special strategies to reduce the amount of data at their disposal. They apply selection and reorganization techniques to adapt their knowledge to new scenarios. Categories are relations that occur due to necessary orders. Thus, each domain has its necessary set of relations and a necessary ordering of entities which define the domain-specific relational structure. This kind of representation has far-reaching consequences in practical applications.

1 Introduction

One of the main problems with artificial intelligence is the fact that the information which artificial intelligence is typically required to handle is heterogeneously structured. Data systems developed independently of one another lead to incompatible data structuring, and thus to semantic breaks. This reflects the different approaches and focuses, the different interpretations and backgrounds of various groups of users.

Ontologies are designed to mitigate this effect. The theory is that ontologies can help to provide a common knowledge base. Ontologies are designed to provide a structure or grid that allows us to categorize information no matter where it comes from and to retrieve that information, just like from an ingenious system of drawers. The general applicability of the grid would guarantee general availability and help to achieve the goal of supporting access from anywhere, and with any degree of precision, giving both scientists access to that knowledge. Ontologies are designed to provide a basis for enabling and supporting multiple perspectives.[1] They aim to provide access to the information source, thus giving a person who applies the ontological grid to that source the kind of information that person expects.

[1] The term is taken from [1].

The task that computer science firmly places in the hands of philosophical ontology is that of mapping the basic principles and structures of reality in an highly generic way, and thus providing an authoritative basis for categorizing and communicating various concepts or symbolic representations of our world. Today, typical approaches attempt to do this by creating models to represent reality. As a result, entities can be represented in many different ways within models. Different perceptions and experiences of our *world* – where the term world is used in a philosophical sense, that is as a unity of physical and abstract entities – thus influence the conceptual exemplification of the models involved and lead to complete different orders, which are incompatible in cases, although they refer to the same part of the world. This is why we still develop, and will continue to develop, different mappings, and different incompatible models and designs. An authoritative structure that allows us to collate varying paths of access to reality can not be designed on this basis. [2)

In addition to a critical appraisal of the options and consequences related to the use of models, we also need a critical appraisal of the extent to which these models are language models of reality. Representations within information processing systems permit a variety of forms. Generalizations and specifications do not necessarily need to be developed along the lines of language models. On the following pages, I will be outlining an approach that allows the meaning behind a representation to come to the fore through ontological categories (cf. [3]).

2 Ontologies as Representations

Language entity oriented specification analyses (language models of reality) maintain a world that is assumed by the model builders. But it remains unclear as to what legitimacy these assumptions have, as the extent to which the model truly reflects the world is unknown. This more or less how the ontological issue arises. What justification is there for information models that refer to a world that apparently everyone perceives in a different way, and can map in a different way?

The difference between the models used in information science, and philosophical ontologies is the methodical approach, and the assertion that it offers a representation basis capable of mapping a world. An ontology based on a "world model", a language model for example, is an ontology "*post quem*". That is, it assumes things, relations etc. which can *not* be assumed – at least not as fixed points of reference. This ordering method is oriented on an approach that "paradoxically needs a known model prior to the original".[4] It is quite obvious that a model of this kind that maps an existing scenario cannot be applied to any other scenario but its own. Its representation only reflects one view of the world, to be more precise the one it projects of itself. Even if it were possible to map all scenarios and relations, a representation would present only *one* view at *one instant*.

2.2 Ontologies as a Basis

From a philosophical perspective, we refer to an ontology when we have a systematic representation of principles whose various relations can adequately describe a subset of the world. The interrelation of these principles constitutes a real world scenario. We refer to these relations as *categories*. An ontology that claims to do this also claims to be authoritative, as the relations that it defines are constitutive for the subset of the world that the ontology defines. This kind of philosophical ontology does not serve the purpose of presenting a unique set of circumstances or a unique representation of the world, as it exists at the moment. Instead, its focus is to provide a basis for a process. After defining basic relations for a specific subset, many other cohesions can be derived from these basic relations. Philosophical ontologies are thus not defined by a hierarchical representation and ordering of the entities they comprise, instead the ordering of the entities in a given ontology, O_1, depends on the definition of the relations.

3 Parts of the Process

In contrast to machine learning, human achievement in the form of outstanding thought is not typically regarded as the result of a quantifiable process, but as the result of a qualitative process.[2] For human thought, the decisive factor is *how* existing knowledge is associated. “Successful” relations are those in which stored knowledge (=known and readily available representations) are modified to reflect new scenarios to allow us to perceive this knowledge as an adequate representation of reality [5],[6]. Because our world changes constantly, our knowledge of that world must also change. This mainly occurs by restructuring existing knowledge and remapping known coherencies to form new ones. This mapping process is based on reality, whereas a model-based approach prefers the perceptions gained via the model to the original. Cf. [4]

As machine learning is implemented by mathematical combinatorics, it allows a multifaceted representation which is totally alien. Machine processes can (theoretically) record an infinite number of things, and each term can (theoretically) be characterized by an infinite number of properties. Correspondingly, existing data can be aggregated in an infinite$^{(2)}$ (infinite to the power of two) number of categories. But this variety does not make sense, as it is not real. It only demonstrates the enormous range of possibilities. But reality is not the sum of all options that can be deduced by mathematical operations. On the contrary, experience tells us that certain relations only exist in specific subsets of the world. We only experience these coherencies in specific areas, but not in all areas. We refer to categories as necessary coherencies, whereas relations can include any possible coherencies. And again, not all relations that are theoretically possible have to be real. But we do not have a systematic scheme of representations that allows us to implement only those relations

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2 Obviously, dynamicism of knowledge was an extremely important topic for Turing too [7]. Turing recommended "educating" computers, as a consequence, an intensive discussion of the question of what learning means ensued [8]. The discussion made it obvious that human intelligence and learning potential are not necessarily equivalent to growth of knowledge, but can even mean reduced performance [9], [10].

that are capable of providing the required coherency.[3] This power of association is specific to human thought; the process can be described as follows.

Humans use special strategies to reduce the amount of data at their disposal. They apply selection and reorganization techniques to adapt their knowledge to new scenarios. We can recognize this as the *analytical* and *synthesizing* part of a process. In one part of the process we *dissect* our knowledge base; in the other we *reassemble* our world. While doing so, we "juggle" with categories. Our aim is to continually modify our knowledge of the world in a way that allows us to generate new knowledge based on existing knowledge, and to modify this new knowledge to reflect new situations. We modify our knowledge of our world by continually creating new relations between entities. We refer to these relations as categories. Without categories, the world would be confused and chaotic for humans. Our understanding of a system of categories is something that allows us humans to cope with the world around us.

Simple relations develop into more complex ones. We can identify new relations by applying basic categories to new situations. A set of simple relations can continually produce increasingly differentiated specifications which allow us to map the world. And the order imposed by these relations impose is reflected as the current context.

Let's assume that O_1 is an image of the world at a given point in time t_1, and that it comprises 3 entities and 3 relations. If the relation R_1 has two digits, we can form the following associations.

R_{11} (e_1,e_2)

R_{12} (e_1,e_3)

R_{13} (e_2,e_3)

The same thing applies to the relation R_2

R_{21} (e_1,e_2)

R_{22} (e_1,e_3)

R_{23} (e_2,e_3) and so one.

And this also applies to the relation R_3. It is understood that relations$_{11}$ etc. depend on their definitions, that is, whether they are transitive or not, and whether they comprise one, two or three digits.

Let's take this image as a representation of a subset of reality, and as part of the thought process. In the *analytical* part of the process, an image is dissected into its parts: entities and relations. If process 1 has e_1,e_2,e_3 and three relations, R_1- R_3, the synthesizing process gives us the relation R_{11} (e_1,e_2) as a new entity e_4, relation R_{12} (e_1,e_3) is generated as a new entity e_5 by process 2, and so on. Relations lead to new entities. Synthesis thus tells us that *all knowledge is a set of facts produced by synthesis*, and not an image of fixed entities.

But thought is a lot more than just the successful adaptation of entities to a subset of the world by the application of relations. It is also the successful selection of characteristics or terms from a variety of options with respect to a specific goal, and its positioning within a specific relationally defined context. It is important to understand critical relations.

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3 Research into expert systems was targeted at representing critical relations and synthetic coherencies which were bounded by knowledge and experience, and evidenced by heuristic processes [11],[12].

3.1 Categories in Taxonomies

Categories are relations that occur due to necessary orders. Let's assume that the original orders, which coincide with the first categories, multiply and continue to differentiate (process 2 and so on). These orders represent meaning. This is quite logical because we say that categorial ordering defines the necessary context[4]. It thus makes sense to generate new meanings via new relational contexts. This also means that semantic content is not defined by the specification of terms, but that the specification of terms is the result of the relational structure.

3.2 Leibniz' Monad

According to the philosopher Leibniz (1646-1716), the world and any relations within it can be described by algorithms.[5] The machine reproducibility of a scientific proposition is a criterion of its truth, according to Leibniz [14]. Leibniz's *ars characteristica* can be viewed in the restricted formal context of his Monad theory. Leibniz defines monads as the representation or reflection of the universe, as its "living mirror". This mirror is simply a specific ordering scheme that reflects a subset of the world in a specific perspective. All monads can be traced back to the same basis. As individual representations of specific facts, they differ by their degree of differentiation and their ordering. This is analogous to the representation of knowledge in an information system. There is a basic set of entities and processes, which is differentiated in specific areas and demonstrates specific patterns of relations[6]; a sensible distinction is made between basic and domain-specific ontologies.[7]

Thus, each domain has its necessary set of relations and a necessary ordering of entities which define the domain-specific relational structure.

The advantage of this approach is that associations between representations can made arbitrarily due to the way the structure is built up. Any subset can theoretically be dissected into its component parts at any time, and traced back to its origins. Parts of this representation of reality that are far apart, can be associated with each other on the basis of their common ground. Of course, one can imagine that an intelligent machine might be capable of making and recognizing these associations itself.

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4. Thus the question as to whether the human brain organizes new information along the lines of existing structures becomes irrelevant: they are new, but based on earlier structures, cf. [6, 332].

5 In his „Dissertatio de arte combinatoria", Leibniz draws up list of all important concepts, and assigns symbols or characters to them. [13, 43].

6 Since the mid 90s, there have been attempts to design and different taxonomies by applying philosophical categories [15], [16].

7 The formal-ontological method of the Basic Formal Ontology (BFO) suggests an approach in which entities are organized along the lines of basic concepts. Within this formally structured framework it would be possible to identify field-specific relations [17], [18], [19].

4 Application

This kind of representation has far-reaching consequences in practical applications. Let's investigate the practical effect that an ontology like the one we designed here can have. This ontology is not characterized by the fact that it presents an image of "existing" facts. Principles and relations are its origin. We need to distinguish between basic ontologies which are applicable to many areas, and others that are only valid within specific domains, in the same way as we distinguish between basic and domain-specific categories. The latter are a product of the former. A variety of taxonomic structures can develop from the basic ontology. Their development depends on the circumstances in which the categories and their iterations are valid. Various branches of development can co-exist parallel to one other. And they will always retain their inter-compatibility. As all states of the total structure can be derived from a base structure, theoretically all states can be inter-associated at all levels [20].

Practical applications show that today's typical technical representations have crisis potential. Let's take enterprises and enterprise workflows that are defined or redefined by the introduction of an information system. The introduction of IT has often led to crises within corporations. Reflecting corporate workflows within a technical system involves a lot of effort. The alternatives seem to lie between an idealizing reference model, and time-consuming and complex engineering of specific details of corporate workflows. The implications and the issues involved with both options are well-known. [2, 317 ff.]

This hypothesis assumes that such things as necessities, and necessary relations exist and that they constitute various domains. This does not mean that specific details in domains, branches or individual enterprises should be denied. Instances occur wherever the development of ontologies stops, that is, wherever process 2 is not followed by a further process to integrate the entities produced by the previous relational structure.

For the sake of argument, let's assume that there are categories that represent necessary corporate relations! Assuming that we can locate these categories, any corporation would be capable (and this is very much in the spirit of Leibniz) of optimizing its own specific position, starting from a common domain-specific and cross enterprise basis.[8] A generic basis and generic knowledge would provide a starting point from which more specific relations could be better defined. [9] Synergies between Philosophy and Practical Applications

From a philosophical point of view, the advantages of a systematic and application-independent ontology construction are obvious. The philosophical

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[8] Traditional expert systems were designed to represent critical relations and synthetic coherencies bounded by knowledge and experience, and evidenced by heuristic processes. With the rise of the WWW and networked environments, the paradigm of information processing has moved away from monolithic, centralized systems towards heterogeneous, and independent information processing networks capable of interaction. Intelligent agents pursue goals independently, and cooperate with other agents. Cf. [21], [22], [23].

[9] Aristotle went so far as to say that economics is not concerned with purchasing and procuring goods – after all animals feed themselves. The ability to order and organize was a defining aspect of human knowledge. [24, 15 ff.].

ontology needs to be developed to provide practical applicability. The decisive question is if a systematic relation between relations and domains, that is families of relations exist, and if their principles can be systematically elicited. [25] provides an attempted proof of concept. The aim is *to provide a principle for generating the complete family of such relations. This will mean providing an account of what formal ontological relations are and of how they differ from relations of other types.*.[10]

The most important goal that philosophical ontology can hope to achieve is precision, and the reduction of redundancy. To achieve this, we need to represent the elements that form the basis of our knowledge in a way that allow best possible access to them. The critical elements that allow this to happen are relations. Relations are the basic framework of the world. And this is why the world is a process and not just a collection of disconnected entities. We need to comprehend entities as a framework of relations, to allow repetition and reintegration. To allow these to interact, it is necessary to identify entities previously identified as heterogeneous sources of knowledge as interrelated representations, linked by categories.

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[10] This topic is discussed by reference to examples of the relations between three and four dimensional ontologies, that is between ontologies that refer to objects, and ontologies based on processes. Again, this assumes ontological perspectivism. Each area of reality could thus be described by a number of ontological perspectives.

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