The Ontology as a Unified Knowledge Graph construction

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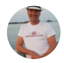

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Abstract
The creation of software systems with an autonomous behavior needs a suitable tool for real world description. Some of those tools have a unified constructions and usually are called "ontologies". The aim of the present article is to analyze some of such construction and to show how can they be described in the Unified Knowledge Graph environment. Along with this, some features of the different constructions of ontologies are commented.

Key words: Knowledge graph, Ontology, ML, AI

Introduction

After the unification of the Knowledge Graph (KG) we from Inato Ltd tried to make some descriptions of "things" from the real world, as interconnected knowledge in the Unified Knowledge Graph (uKG) [1]. So, we discovered a lot of different semantic sets with analogous constructions. The elements in those constructions were with similar semantics. This led us to a new understanding of the widely used term "ontology".
Studying the work of other teams (the list is too long to fit in this material), we encountered the lack of a unified generally accepted definition of ontology. All the more or less fitting definitions had one thing in common- they do not use simultaneously models and their instances as an element of the construction for the construction of ontologies . This was ignoring the opportunity to use the synergy between models and their instances built into our Unified Platform for Innovations (UPI) which is with Semantic Network Based Architecture [2].
Another problem which we have encountered is connected with the widely used scheme "one ontology-one Data base" for ontology support, since we need a semantic environment with more than one different ontologies for our systems.
To continue our development, we accepted as a working definition that an ontology is *a set of semantically similar objects with the same specialization*[1] *of connectivity between them, which can be both models and instances of a models*. So the uKG-construction "ontology" can be considered as a means of forming a generalized representation of the semantics of a set of semantically similar objects.
This made a lot of questions clearer. For example, the questions about how an ontology can be presented as a construction of models and instances of a models, how it can be defined an "entry point" (or more than one entry points) in the ontology construction from which all of the ontology elements are accessible by navigation, and so on, and so on.
That's how the question *How to describe an ontology-construction?* arose.

In quest of a description of the ontology-construction

We have created in the uKG-environment several ontologies and realized that it is not that easy to create a general description suitable for all possible kind of ontologies, representing "things" from the real world. For this reason, we are not dealing with this task at the moment. Instead, we decided to create an initial set of descriptions of ontologies so that we could work on creating a simplified formalized version of natural language[2] and its interpretation. This allowed us to define an initial set of general requirements for the creation of a descriptions of ontology, as follows:

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[1] This refers to the specialization of classification arcs in the ontology construction, as is described in [1].
[2] This goal is defined in [1].

- Defining the model for specialization of the classification arcs, which form the construction of the ontology and give its general semantic representation
- Defining the models (or class[3] of models) of the objects in the ontology, and of their roles if they are involved in the ontology
- Determining the storage places of the various models involved in the construction of the ontology
- Defining an entry point in the ontology from which all elements of the ontology are accessible by navigation, including the models used in its construction
- Defining standard functions for processing ontology content if any.

We are not sure that this is the right and full set of requirements. But the set is enough to allow us to continue our work forward. It is obvious that in our future work we will create many new ontologies which will maybe help us add a new requirement to the set.
For now, we can share the ontology-constructions we created as follows:

1. Classification ontology

The classification ontologies have hierarchically organized construction. A special kind of objects supports the ontology construction. In the uKG-environment those objects have a model Catalogue[Model]. The classified objects in such ontology can be different models or instances of different models.
In the general case there are no restrictions on the number of classifications of the same object (including Objects[Catalogue]) in one the same catalogue in cases when some technological sense requires this.
The connectivity between Objects[Catalogue] and the classified objects is supported by specialization, presented by arc-model Classification[Model].
The classification ontologies are a means of incorporating semantically heterogeneous objects in ordered environment. This can be the knowledge space of the agent, as is defined in [1].

2. Single ontology

The single ontology consists of only one kind of class of uKG-objects. They have a hierarchical organized topology with a beginning node as an entry point in the whole space of the ontology. The beginning node as an object is model which represents the specialization of the classification arcs in the ontology.

2.1. Single homogeneous ontology

The elements of this kind of single ontologies are instances of the model, that is, of the beginning node in the topology of the ontology. The topology itself is a one level taxonomy. An example of such kind of ontologies are the ontologies for measures. Every such ontology has a model representing the specialization of the arcs in the ontology construction. The elements of such ontologies are instances of those model.
The Time measures ontology is a typical ontology for measures. The beginning node (and entry point) of the Time measures ontology will be Time measure[Model] and the elements of the ontology will be Second[Time measure], Millisecond[Time measure], Hour[Time measure] and so on.
Using the notification scheme introduced in [1], the construction of this ontology can be described as follow:

```
Time measure[Model]
     Clsf: Time measure[Model]; Second[Time measure]
     Clsf: Time measure[Model]; Millisecond[Time measure]
     Clsf: Time measure[Model]; Hour[Time measure]
     …..
```

[3] The uKG-definition of the term "class" is done in [1].

This ontology will ensure not only the time measures definitions, but also a functionality for conversion from one measure to another. The functionality will be embedded in the arcs in the ontology construction, in a form of a content of Clarifying data[Value], as is described in [1]. The description of the functionality can be a mathematical expression or a software realization of its interpretation. The second variant transforms the ontology from a passive semantic description into an active uKG-node, capable of providing services for a measures conversion. This is a very simple example of a collaboration between uKG-nodes/objects, as is shown in [3].

2.2. Single nonhomogeneous ontology

All elements (except terminal elements) of such an ontologies are different types of models. Its topology is a multilevel taxonomy. Every element from the middle levels is a model for elements of the lower level and the model itself is an instance of a model from the higher level. The beginning node as a model ensures the specialization of the classification arcs in the ontology.

An example of such kind of ontology can be the ontology of colors. The color itself is the human acceptance of an electromagnetic emission. This means that the beginning node of the ontology can be Electromagnetic emission[Model]. The two branches of the ontology for colors would look like this:

```
Electromagnetic emission[Model]
   Clsf: Electromagnetic emission[Model]; Light
   emission[Electromagnetic emission]
      Clsf: Electromagnetic emission[Model]; White[Light
      emission]
         Clsf: Electromagnetic emission[Model]; Blue[White]
            Clsf: Electromagnetic emission[Model]; Azure
            blue[Blue]
            Clsf: Electromagnetic emission[Model]; Sapphire
            blue[Blue]
         Clsf: Electromagnetic emission[Model]; Red[White]
            Clsf: Electromagnetic emission[Model]; Light
            red[Red]
         .........
```

Using the same approach, we can add to so constructed ontologies radio waves, microwaves, infrared, ultraviolet and why not sound waves. But in this case, we should introduce as the beginning of the ontology an additional element representing the more general concept of "emission".

A very simplified version of the ontology of living beings has the same construction, despite the fact that it belongs to a radically different semantic domain:

```
Living being[Model]
   Clsf: Living being[Model]; Plant[Living being]
      Clsf: Living being[Model]; Flower[Plant]
         Clsf: Living being[Model]; Rose[Flower]
   Clsf: Living being[Model]; Animal[Living things]
      Clsf: Living being[Model]; Mammal[Vertebrates]
         Clsf: Living being[Model]; Cat[Mammal]
```

```
Clsf: Living being[Model]; Lucy[Cat]
```

In [4] is presented a case for forward reasoning (or deduction), shown by the example: *Rule: All men are mortal, Observation: Socrates is a man, Conclusion: Socrates is mortal*. A similar case can be discovered and in the presented above ontology of living beings: *Rule: All cats are mortal, Observation: Lucy is a cat, Conclusion: Lucy is mortal*. The comparison of the two cases raises many questions about the essence of the process of forward reasoning (or deduction), its realization in the environment of an ontology and in general about the use of ontologies in different processes of semantics processing. This is one of the directions in which our future efforts will be directed.

3. Role[4]-based ontology

The roles in this kind of ontology are created according to different models. Each role corresponds to an inverse role, which creates an inverse connectivity between the reference objects of the two roles and thus provides navigation in the opposite direction in the space of the ontology.

The model of the inverse role is pointed out for each kind of role in its model. At the moment of creation of a connectivity between two referent objects by some kind of role, the creation of the invers connectivity between the same objects by the corresponding inverse role is obligatory. The lack of inverse connectivity is not a lack of semantics/knowledge, but a technical omission in the support of uKG.

A good example of role-based ontology is the ontology which presents a connection between relatives. The main reason for determining kinship is the transmission of genes . Let us consider for example kinship represented by genes borrowing and providing which is a transfer of semantics in the literal (by genes) and figurative (ontology) sense. Every human borrows genes from their mother and father and they in turn also borrow genes from their parents. This connectivity forms an ontology of kinship based on genes borrowing the two initial levels of which can be presented as follows:

```
 <child-name>[Human]
    Clsf: Kinship, {Gene borrowing}[5]; <mother-name>[Mother]
    Clsf: Kinship, {Gene borrowing}; <father-name>[Father]
```

and the inverse connectivity:

```
<mother-name>[Human]
    Clsf: Kinship, {Gene providing}[6]; <child-name>[Child]
 <father-name>[Human]
    Clsf: Kinship, {Gene providing}; <child-name>[Child]
```

And in both directions of semantics (genes) transfer the specialization of the classification arcs is presented with Kinship[Model]. The models Gene borrowing[Model] and Gene providing[Model] are classified as construction of Kinship[Model].

By the way this kind of ontology has some peculiarities which are:

- Thanks to the inverse connectivity, practically every element of the ontology is an entry point for the elements in the whole ontology
- Every element of the ontology can be considered as a beginning element of the corresponding sub-ontology and the ontology itself can be a part of some upper level ontology

[4] The definition of a role-construction is done in [1].

[5] This designation indicates that in the Clarifying data[Value] of the connecting arc is pointed out the gene borrowing as an indication of a type of Kinship.

[6] This designation indicates that in the Clarifying data[Value] of the connecting arc is pointed out the gene providing as an indication of a type of Kinship.

In addition to that, it is possible that such ontologies have parts in which the classical tree-topology is violated. Such case is when the same element may provide semantics to more than one higher-level element. It leads to the shrinking of the corresponding level of the ontology. In the example of kinship, this is the case of a common ancestor along several lineages. Continuing the genealogy to antiquity, these cases of a common ancestor will become more frequent, and the ontology will shrink more and more. And if what is written in the Bible is true, in the end we will come to only two elements, representing Adam and Eve!
The human social evolution has been enriching the kinds of kinships by introducing other variants of connectivity through:

- Co-sharing inherited genes
  Thus, kinships of brother-brother, sister-sister and brother-sister are determined. An example of presenting such a connection would look like this:

```
John[Human] Clsf: Kinship, {Sharing genes[Model]} Tom[Brother]
Tom[Human] Clsf: Kinship, {Sharing denes[Model]} John[Brother]
```

- Joint provision for inheritance of sharing genes
  Thus, kinship of mother-father is determined. An example of presenting such a connection would look like this:

```
John[Human] Clsf: Kinship, {Provisioning genes[Model]} Mary[Mother]
Mary[Human] Clsf: Kinship, {Provisioning denes[Model]} John[Father]
```

A lot of indirect kinship connections can be found in the ontologies presenting kinship. - for example, for cousin, nephew and so on. The paths presenting those kinships connections will include not only Gene borrowing/providing, but also Gene sharing/provisioning.
Every such indirect kinship connectivity can be duplicated with direct connection realized through an appropriate role model. The specialization of such direct connection will be Gene provisioning if at least one connection in the path is with such specialization.
This example of ontology convincingly reminisces the popular construction "Family tree", but in the case the element "Family" is missing.
This is only a disadvantage at first glance. In fact, an ontology includes relatively stable structures in terms of construction and presence. Unfortunately, the social construction "Family" is not only unstable over time, but also as a construction appears in different forms - family with administrative registration, registration according to the rules of different religions, cohabitation, even incidental intimate communication and so on.
This uncertainty of the construction "Family" is reflected in the example through its absence. Indeed, Provisioning genes-connectivity has characteristics that we humans are accustomed to attaching to our ambiguous understanding of family. Those characteristics can be included in the Clarifying data[Value] of the corresponding arc with Clsf: Kinship in the same place the as description for “provisioning genes” is included.
After adding these characteristics, the necessary description of the "Family" construction is provided, albeit in an implicit form. And this is enough to generate a graphical presentation of a Family tree in which one can see the corresponding constructions of a family in an explicit form, regardless of the above remarks.
Using the semantic construction "Role" it is possible to create an ontology, or maybe a set of connected ontologies representing organizational structures from the public and governance area. Those ontologies are interesting with the very common connection between people- collegiality. Such a connection arises between a person, for example working in the same department of an organization. In the general case, when working with people in the department, it can be assumed that collegial relationships arise with all employees in the department. Therefore, the creation of a collegial connection can be linked with the employment in a department. That is, reflecting the appointment in the ontology of the respective organization, the connections representing collegial relations can be automatically created.

4. **Compound ontology**

The compound ontology is composed of two or more other ontologies. The semantics of the compound ontology are not always a generalized representation of the semantics of its elements, that is of the included in its other ontologies.

A good example of this is the compound ontology representing the two kind of measurement units for wave emission. One of them is the Meter (m) and the other one is the Hertz (Hz). This compound ontology can be easily presented using a construction of the single ontology, as is illustrated above:

```
Meter-Hertz[Model]
    Clsf: Meter-Hertz[Model]; Length measure[Model]
       Clsf: Length measure[Model] Meter[Length measure]
       …….
    Clsf: Meter-Hertz[Model]; Frequency measure[Model]
       Clsf: Frequency measure[Model]; Hertz[Frequency measure]
       …….
```

Questions instead of conclusions

In fact, the compound ontologies raise the general issue of connectivity between different types of ontologies. And maybe the more general questions are whether there is an Ontology of the ontologies (OoO), how it is constructed and where it is situated inside the uKG? Maybe the issue with the OoO is a key one?!

The presented in this article approach for unification of the construction of the ontologies covers not only all existing constructions but of course the ontologies constructions which will be created in the future. The presented examples of different kinds of ontologies of course do not include the whole content of them- they only illustrate the ontologies constructions.

But some kinds of ontologies have more than one version used in real life. For ontology for the Living beings, can be pointed out an academic and a lot of used in daily life versions. Sometimes it is possible to be used the wrong, or inappropriate for concrete task version of an ontology. The possibility of using wrong (incomplete, etc.) semantics, including one derived from ontologies can lead to wrong behavior of a system.

It is known a philosophical interpretation of this issue, which can encourage looking for algorithms which are wrong, but useful[7]. But to achieve a semantic processing with a philosophical level of abstraction is necessary to have a big number of semantic descriptions concerning the real world and a very complicated algorithms for semantic processing. Obviously, the first task is to create efficient means of creating ontologies with various constructions and to introducing content into them.

At the moment our efforts aim to solve this task

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[7] Perhaps someone guesses that this is a paraphrase of Peretz's thesis that "All models (metaphors) are wrong, but some are useful"- [7], [8] and [9].

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