COMPOSITE SEMANTIC RELATIONS BETWEEN ACADEMIC CONCEPTS IN SEMANTIC NETWORKS

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Abstract

The studies of academic knowledge organization principles and its representation in language appear to be of great significance today because they shed light on some fundamental theoretical issues related to the language of science as well as contribute to some applied research objectives, such as designing terminological semantic networks and electronic dictionaries based on them, ontologies, expert knowledge systems, natural language processing, etc. Academic concepts are expressed by technical terms that constitute the terminology of a certain field of knowledge. Their arrangement within such a terminology system represents a model of the fragment of objective reality (see Leychik 2006). As C. Khoo and N. Jin-Cheon (2006) say, “while concepts are the building blocks of knowledge, relations act as the cement that links up concepts into knowledge structures”. The systematic character of technical terms can be modeled and studied by means of a terminological semantic network that can illustrate the adjacent concepts. One of the key problems here is what the prototypic semantic relations are that link two concepts that belong to the same category or different categories.

This paper is devoted to the study of certain prototypic semantic relations between two vertices that are linked to one and the same action (that may be expressed by a technical term and represent another vertex of the category Process or by a word of general vocabulary that is not part of the structure). In this respect their relationship is predetermined by the existence of such action and is mediated by it. Since the two vertices are linked to this mediating vertex by different types of semantic relations (the agent of the action – “Ag”, the instrument of the action “Inst”, etc.), the relationship between them appears to be composite based on their roles in the action. Thus, we define and discuss specificity of the existing types of such composite semantic relations that link the agent of the action and its instrument “AgInst”, the instrument of the action and its object – “InstObj”, etc. The peculiarities of their representation in specialized texts and the structure of the technical terms are analyzed. I draw most of the examples mainly from the terminologies of nanotechnology and space research, as well as other fields of knowledge when necessary. The technical terms and their definitions were collected from terminological databases, dictionaries and fragments of specialized texts.

Keywords: semantic network, semantic relation, academic concept, technical term, category, definition

1. INTRODUCTION

Today, research into academic knowledge organization and its representation in language appears to be of great significance. One of the reasons that stand behind this fact is that “scientific fields have been highly productive in recent years in the addition of new terms and phrases to the lexica of languages all over the world” [Wessels, 2010]. Since academic concepts are expressed by technical terms that constitute the terminology of a certain field of knowledge, their arrangement represents a model of the fragment of objective reality [Leychik 2006]. Recent studies have demonstrated that a semantic network can be used to model the structure of a terminology and study the organization of academic or professional knowledge that the technical terms express. As C. Khoo and N. Jin-Cheon (2006) say, “while concepts are the building blocks of knowledge, relations act as the cement that links up concepts into knowledge structures”. Thus, the terminological semantic network can be used to reveal and study the systematic character of technical terms that express the adjacent concepts. Such combinations of interlinked concepts are sometimes referred to as “neighborhood structures” [Steyvers & Tenenbaum, 2004]. So one of the key problems here is what the prototypic semantic relations are that link two concepts that belong to the same category or different categories. This paper discusses the types of composite semantic relations between two concepts that are based on the semantic relations of these two concepts with a common concept of the category Process.

2. PRINCIPLES OF TERMINOLOGICAL NETWORK FORMATION

The essential part of our approach to building a terminological semantic network of a particular domain involves two important requirements. The first one is the differentiation of vertices into types that reflect the natural stratification of technical terms according to the categories of concepts that they express. The classification of concepts into categories is based on the specificity of their referent that can be of material and non-material nature. Those of material essence are subdivided into the ones of natural origin (Natural object/objects, Substance, Locus) and artificial origin (Mechanism, Instrument, Material, Construction/man-made locus). The referents of non-material nature refer to the following categories: Process, Characteristic, Actor, Situation/event, Ideal phenomenon. Representing a very high level of abstraction, these basic categories, if necessary, may also be subdivided into more specific subcategories that in turn can be classified into thematic groups that are particular to a certain domain (for further information on the issue see Latu, 2016).

The second requirement is the differentiation of arcs (that are semantic relations) into prototypic types that can be potentially established between concepts of definite categories. A terminological network, unlike an ontology, involves technical terms only and does not have vertices expressed by general vocabulary. In this respect it is important to note here that the number of prototypic semantic relations between concepts is limited. They appear to be productive and not specific to a particular domain. Among these are AKO semantic relation (links the generic term and its hyponyms), Loc semantic relation (links the referents one of which is the exact location of the second one) PO semantic relation (links a holonym and its meronyms), Ag/S semantic relation (links two referents one of which is an action and the other is the subject of this action that is the exact doer or an active party), Obj semantic relation (links two referents one of which is an action and the second one is considered to be the object of influence or change of this action), Inst semantic relation (links the referents one of which is an action and the second one is considered to be an instrument, a means or an implement in the action), R – “result” (links the referents one of which is an action and the second one is is seen as the result of the action), ISA semantic relation (links two referents one of which is an aggregate the second one is included into) ,etc. (to learn more about different types of semantic relations that are established in terminological networks see Latu, 2016). The concepts that are linked by a semantic relation of a certain type are considered to be adjacent. The number of adjacent concepts as well as types of semantic relations between them appears to be specific to a particular concept. Defining the types of the semantic relations helps understand the multifacetedness and specificity of systemacy of technical terms within a terminology.

As adjacent concepts are normally expressed in same contexts, the information about their semantic relations is obtained from different sources. First of all, these are definitions in specialized dictionaries because, as a rule, technical terms are used to define other technical terms of the same field of knowledge or allied sciences. However, not all adjacent technical terms appear in definitions of a certain specialized vocabulary unit, and links with them can be extracted from academic texts, such as journal articles, monographs, etc. Sometimes the link with an adjacent technical term that is used in the definition is also represented in the structure of a multi-component technical term as well [Latu, 2017]. Very often this is a subsumption (AKO) relation, but other options are also possible.

3. COMPOSITE SEMANTIC RELATIONS AND LACUNAS IN TERMINOLOGICAL NETWORK

However, very specific groups of “neighborhood structures” of adjacent concepts that appear in one and the same contexts were defined in the course of analysis. Such concepts are not linked to one another directly, and the relationship between them is mediated by the existence of a certain concept of the category Process that they both are related to (see Figure 1). In other words, there are vertices that are linked to one and the same action by ordinary types of semantic relations that mark them as the subject (Ag semantic relation), the object (Obj semantic relation), the instrument (Inst semantic relation) or the result (R semantic relation) of it. In this respect, the presence of a relationship between such vertices is totally predetermined by this certain action. But for this action, such concepts would never be associated with one another because there would be no reason to do that. Since the two vertices are linked to the concept of the category Process by different types of semantic relations, the link between them appears to be composite based on these two direct links with this action. To sum up, such composite relationships are based on the types of semantic relations that are potentially established between concepts of various categories with the concepts of the category Process that mark the roles that they are considered to have in this action.

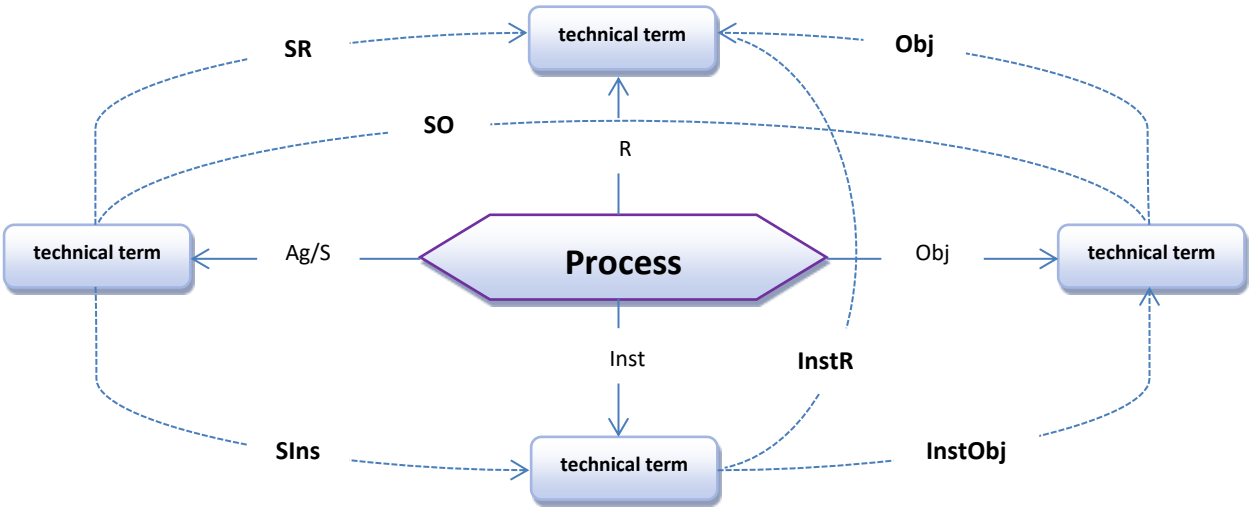

Fig. 1. Composite semantic relations between technical terms that are linked to a common technical term of the category Process.

It is also important to note that actions linked to academic concepts appear to be represented by lexical units of different strata. In many cases these are academic concepts as well that are expressed by technical terms. And, consequently, they are independent vertices together with other academic concepts being constituent elements of the terminology and its terminology network model. On the other hand, there are concepts that are not expressed by technical terms of this particular field, even though they are linked to certain technical terms in a similar way. These are expressed by the words of general vocabulary. For example, there are such lexical units as ‘study’, ‘research’, ‘observe’, etc. that express actions, but they are not technical terms. At the same time they link in a cluster academic concepts of a certain field of knowledge, where in each particular case there is a concept of what is being researched, by means of/with the help of what it is being done and the definite actor the technical terms for which may also vary. Since such words are not technical terms, they are not part of the terminology and, consequently, are not represented in the terminological network model because its vertices are expressed by technical terms only. This fact creates lacunas, gaps in the terminological network structure where definite element that serves as an instrument of investigation of a very specific object and the definite actor who uses it appear unrelated, since there is no technical term for the action. Practically, this is how the necessity for defining such composite relations between them became obvious. The problem of gaps in terminological networks and the reasons why some concepts used in academic discourse are not expressed by technical terms, as well as other issues that this problem trigger represents a different broad field of investigation, requires separate study and thus is beyond the scope of this research.

4. TYPES OF COMPOSITE SEMANTIC RELATIONS

In the course of analysis of the "neighborhood structures" that concepts of the category Process establish with adjacent academic concepts, the following six composite semantic relations were defined: the semantic relation between the item that is seen as the subject that performs the action and the item that is seen as the object of influence of this action (SO semantic relation), the item that is considered to be the subject of the action and the item that is used as an instrument to perform it (SInst semantic relation), the item that is seen as the subject of the action and the item considered to be the result of this action (SR semantic relation), the item that serves as an instrument in the action and the item that is the object of influence of this action (InstObj semantic relation), the item that serves as the instrument in the action and the item that is considered to be the result of it (InstR semantic relation), the object of influence and the item that is seen as a result of the activity (ObjR semantic relation).

SO semantic relation

As it has been noted, SO semantic relation is a composite semantic relation based on Ag and Obj semantic relations and, consequently, links the referent that is considered to be the subject that carries out the action being its prime initiator or playing an active part in it, on the one hand, and the referent that is seen to be the object of influence of this action. Thus, this relationship demonstrates who or what applies physical or mental force to what. What vertices are linked together by this semantic relation largely depends on the action itself. The object of influence may be the referents of the category (natural) Substance, (man-made) Material, Natural object that are somehow manipulated or investigated. The subject in this neighborhood structure may be the referent of the categories Actor, Mechanism, Natural object. The relationship between the two concepts is reflected not only in academic texts such as definitions in specialized dictionaries, research articles and books, but also in the structure of some multi-component technical terms that include the technical term for this adjacent concept as one of the elements. For example, the technical term **astrophysicist** is linked to the technical term **star** by SO semantic relation that is clearly seen in the definition:

"**astrophysicist** - a scientist who studies the physical and chemical structure of the **stars**, **planets**, etc."

[Oxford Learner's Dictionary]

It is important to note, that this relationship is much more likely to be reflected in the structure of the technical terms that appear to be the subject (linked to the action by Ag semantic relation) and not the object of influence (linked to the same action by Obj semantic relation). If we consider the technical term **cosmologist**, the structure of it contains the lexical unit **cosmos** that in technical astrophysics usage is synonymous to the **universe** that this scientist studies:

"***cosmologist*** *- a scientist who studies the* ***universe*** *and its origin and development*" [Oxford Learner's Dictionary].

These two examples demonstrate the case when SO semantic relation is reflected both in the definition and the structure (the underlying form) of one of the adjacent technical terms. The technical term for the item that serves as an object of the action does not, normally, contain the technical term for the subject in its definition or structure though.

SInst semantic relation

SInst semantic relation links the concepts that are related to the common action by Ag and Inst semantic relations therefore demonstrating the relationship between who or what carries out the action and with the help of or by means of what. Even though this relationship may be reflected both in academic texts and the structure of technical terms, in certain cases when the relationship is too obvious or is supposed to be known or expected, text with the joint usage of such adjacent technical terms may not be frequent. The link between such technical terms as **astrophysicist**, **astronomer** and **coronagraph** illustrates the SInst semantic relation:

"***astronomers*** *use an instrument known as "****coronagraph****" to isolate the reflected starlight*" [O'Neill, 2017].

It is worth noting that neither of these two concepts has this relationship reflected in their definitions, since both of them are not considered to be defining features for each other and if mentioned, would represent superfluous information.

InstObj semantic relation

InstObj semantic relation links the item that is seen as an instrument in the action and the item that the

action is directed at. The referent that is linked with the process by the Obj semantic relation may be the object of study or investigation, but also the referent that is being changed in the course of this particular action. Thus this referent may represent any substance, material, phenomenon, man-made or natural physical body. A rather obvious example of the adjacent concepts linked by InstObj semantic relation is the neighborhood structure of **coronagraph** and (**solar**) **corona**. It is clearly seen that one of the terminological elements in the structure of the multicomponent technical term for this specific type of telescope was borrowed from the technical term **corona**. As the necessity to create such a device was predetermined by the existence of the concept for the specific area of the Sun's atmosphere, the technical term for it was used as a terminological element in the coining process to show their adjacency. This relationship is also reflected in the definition of the technical term **coronagraph**:

"*an instrument for observing the Sun s **corona**, which is normally seen only at a total solar eclipse*" [Mitton, 2001].

It is worth noting, in this respect, that this relationship is reflected neither in the structure of the technical term nor in the definition of the concept corona that serves the object of investigation.

SR semantic relation

As for the SR semantic relation, it links the referent that is considered to be the subject of the action and the referent that is seen as the result of this activity. Similarly to the previously discussed composite semantic relations, SR semantic relation can be reflected in the structure of technical terms, definitions and contexts. For example, **aerosol generation system** generates **aerosol** with this fact represented in the structure of the technical term for this device. The same semantic relation is established between the technical terms **optical transmitter** and **optical signal** that is reflected in the definition:

"***optical transmitter** is a device converting input electric signals into output **optical signals** transmitted in an optical transmission medium*" [Rusnano thesaurus].

InstR and ObjR semantic relations

The definition above also reveals the relationship between the concepts expressed by the technical terms **electric signal** and **optic signal** that is the example of the ObjR semantic relation. InstR and ObjR composite semantic relations link the referent with the help of which the action is carried out and the one affected by the action with the referent that is considered to be the result of this activity. Thus in the process of conversion an electric signal undergoes changes the result of which is an optic signal. Sometimes ObjR semantic relation is parallel to PO relationship between the referents that represent a material and a composite material or a man-made object that is made of it.

5. CONCLUSION

The discussed semantic relations are prototypic and, as it has been illustrated, are established between the concepts that are linked to one and the same action. Since they are based on two different semantic relations that these concepts have with such process, they are composite in their structure. Their specificity, as compared to other semantic relations that are established in the terminological network, is that the possibility to establish them is preconditioned by the presence of a common concept of the category Process. The latter can be expressed by the technical term and, consequently, be one of the vertices in the terminological network or by a word of general vocabulary that is not an element of the model. The notion that such semantic relations are important in organization of academic knowledge is supported by the fact that they are reflected not only in fragments of texts in academic papers, but also in the structure of technical terms and their definitions, pointing at the features of the concepts that are considered significant in their perception.

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