Are Ontologies Involved in Natural Language Processing?

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Abstract

For certain disable persons unable to communicate, we present a palliative aid which consists of a virtual pictographic keyboard associated to a text processing from a pictographic scripture. Words and the grammar are given as pictograms. The pictographic lexicon must be organized following the mental lexicon of the user to propose the pictograms of grammar in order to facilitate his (her) task of writing. We discuss the utility of ontologies in the organization of lexicons and in the building of texts.

Ontologies and Natural language

The problem

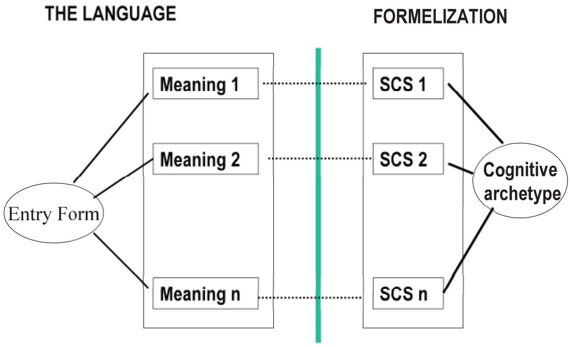
In computer science, ontologies are aimed to structure the concepts of a domain. In the language field, ontology will structure the concepts of a language.

The languages can be considered as systems that describe the world. Therefore, the question of the relationship between the structure of language and structure of ontologies have to be risen. There are several ways to structure a language: i) following two sets of units: the vocabulary and the grammar; ii) following an applicative and cognitive structure, where operations apply to operands; in the latter case, we must see how the language defines operations and operands.

In both cases, the question of the organization of the lexicon and the description of words arises. The role of grammar, that enables to build sentences, is defined in the first case by rules of grammar. In the second case, we consider semantic grammars, expressed by abstract operations and performed at the level of observable by a syntax, morphological changes, and certain words of the lexicon. The grammar of a language contains complex operations specific to that language, which can be recognized as the result of combinations of elementary operations[1]. Here is an overview of these operations for the French language.

Lexicon and ontologies

The lexicon of a language is a collection of words designating certain entities in the world. Our access to reality requires a construction of representations and interpretations given through our perceptions. Everyone can easily notice that an entity or an idea can receive a name in one language and not in another one, although this entity or that idea seems to fall under the same concept.



To a same entry in the lexicon, several meanings are associated;
they are described by SCS's.

Figure 1: Polysemy

It is in the concepts level that ontologies are described. In computer processing, we have to describe these concepts. A concept refers to several words; words are polysemic and therefore refer to several concept. It is not with words that we can describe ontologies, except if we reduce them to specific domains, which are known as domain ontologies. However, we expect that the systems of languages can describe all domains. The polysemy of words lead us to describe concepts by combinations of primitive designating most basic concepts. In order to describe concepts, we propose to use cognitive primitives [Desclés, 1987,1990] that we use to describe the different meanings of words in the lexicon [Figure 1]. On one hand,

See the program of the team LaLIC, Paris IV Sorbonne, in particular [Desclés, 1990].

ontologies can be linked with the language through primitives. The words are polysemic, but one meaning of a word belongs to one semantic field, which itself can be described by using primitives. Within a semantic field, close meanings can be linked by networks of synonyms (figure 2). This idea is the basis of WordNet, where words are set together around a same concept into Synsets. On the other hand, several meanings are associated to a given word; these meanings are described by arrangements of structured primitives. These patterns are called semantico-cognitive scheme (SCS, [Desclés, 1990]).

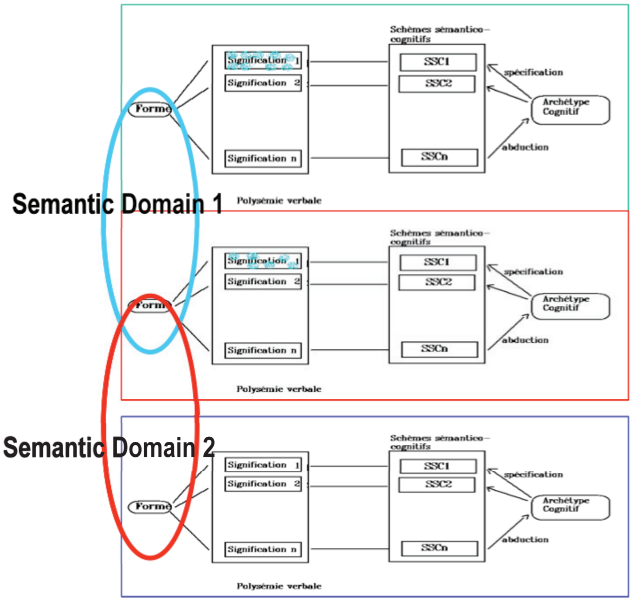


Figure 2: Polysemy and semantic domains.

Semantico-cognitive schemes and cognitive primitives

We have defined different categories of primitives able to describe the meanings of words: structuring primitives, that contribute to organize the grammatical patterns, and empirical primitives, which are closer to perception, manipulation and categorization made by human beings.

The description of the lexicon using primitives demands to choose a basis of primitives and a law of composition in order to represent the meanings of the words. The language is used to represent the world, and we can consider it as a naïve physics; so we found the primitives from notions which are used in physics. Physics considers what is stable, and what changes. Structuring primitives are founded on perception and action, which are characteristics of human behavior and through what human beings build their mental representation. So, we define primitives able to represent static, kinetic and agentive primitives. Moreover, empirical primitives are chosen in order to describe objects of the world using their abstract properties.

Role of ontologies in the production process of language by humans

An assistive application of NLP in speech disability

How can this description of semantics (words, concepts) find applications and how can it proof its cognitive adequacy in the NLP?

In a project aimed to help people without speech, without alphabetic scripture, and very severely disabled, communication is established through pictograms. The idea came very quickly to build sentences from an ordered series of pictograms. This project raises a number of questions that we have treated in some articles [Abraham]: i) What is the status of pictograms if they are used to rebuild sentences?; ii) how can the lexicon be organized to give quickly access to words? If the only means of communication is established through the pictograms, several questions arise: How can they be arranged on a virtual keyboard so that the organization of this virtual keyboard matches the mental lexicon of users?

For a user, the writing process from pictograms is divided into several steps:

1. Find the words represented as pictograms on the screen;
2. Organize them in the range they appear in the sentence;
3. Apply grammatical operations which assign them a role in the sentence.

The three steps are usually carried out simultaneously in our minds. We have difficulties to advance evidence that our thoughts proceed in that order. What we can see, is the learning situation accompanied by a speech therapist. It is difficult to say whether we think the situation as described here in three steps, and how words come to us to put a situation into words, knowing that the construction of the sentence has its own rules and that we fully integrated them into our language. The problem is tantamount to best simulate our writing by giving an organized lexicon to the user, and allowing him (her) to indicate the grammatical operations the result of which is given by : i) places of words in the sentence; ii) morphological changes, which result from grammatical operations that we believe semantic. The places of words can be handled easily by the user, but grammatical operations which are carried out by morphological changes must be indicated. Pictograms of grammar will be given to the user in a separate category, in order to process the corresponding syntactic category easily.

From semantic theories to applications based on ontologies

The theory of applicative and cognitive grammar (ACG, [Desclés, 1990]) analyzes the language following an operator / operand structure: different types of operators receive typed operand: operators on names are distinct from operators of verbs or of adjectives. In a pictographic writing system of words, whatever the organization of the lexicon, lexical pictograms must bear the marking of their syntactic category since this category involves a series of possible operations on this icon.

The lexicon must also be organized into semantic fields. The pictograms carry figurative representations of semes, as well as their syntactic categories. Two organizational approaches are possible, depending on the processing that we made with this new typewriter. At the first level, either we find several words in different syntactic categories dealing with the same semantic fields, or, toward a broader range, a syntactical level; under this syntactical level, lower levels are organized into micro-semantic fields. In both cases, the problem of polysemy arises: a polysemous word can belong to several semantic categories, with different graphical representations, since images visually represent a designated entity. Such set of representations is not economical because it multiplies figurations of a single word. Moreover, problems arise if the word has abstract representations. In this case, conventional symbols are to be found and understood. One single representation of a good representative of the word should be a more economical solution, and perhaps easier to manage (in presentation and research processes) in a very large dictionary.

Domain ontologies

It must be noticed that the semantic categories do not cross syntactical categories, so, it makes more sense to divide the first level into syntactical categories; then, each syntactical category is divided into semantic domains: these domains are organized according to ontologies which rank the images of the world following human point of views. At the first level, broad areas of the world are found. In each sub-category, semantic entities share contextual relations of belonging to the same subdomain.

So, the lexicon is structured into ontology domains, in which each semantic subdomain (SDS) is linked to its higher domain by an inclusion relationship.

For example, at the first level, we find SDS names, adjectives, verbs, grammatical operations and a set of sentences usefull for emergency.

Then, in the SDS, names are structured into :people, animals, artifacts, ... In a given SDS, the pictograms represent entities linked by a semantic relationship. The organization of these SDS is more or less empirical, constrained by the readability of icons on the screen: of course, the more numerous are icons on the same page, the more they are small; in this case, a lower level containing pictograms collected by a new semantic criterion is created. So the depth of trees depends on the number of icons placed in each SDS.

The vocabulary is built from entities of the world; they are represented figuratively. These entities represent words that are polysemic, and can therefore designate entities belonging to other semantic subdomains. The lexicon is not presented in its entirety following an ontology for several reasons:

The image found in a semantic category is that of an object chosen to represent a word. This image gets a double status, and depends on the processing it will receive: for the person who sees and selects it, this image represents a word, identified by the entity; Then, once selected, the picture becomes a scripture of the word, and does not necessarily represent the entity which helped to find the word. The user who chooses his words switches from the world organization to the world of language, from an ontological organization to a writing system. We must take account of the writing process of the user: it must find its words quickly: it looks for them as entities of the world, kept in the category where best representative of the entities designated by the word are stored. He thinks the word, to find an image even if this image does not refer to the entity that identifies it. Once the image is found, it becomes only the scripture of the word, and it often corresponds to another entity than that contained in the lexicon.

The lexicon contains only grammatical information associated with words, without semantic features. The semantic indications are given by the images of words to find the words. It is only at this level of retrieval that ontologies are usefull.

The solution of including all entities, therefore deploying the polysemy, would have the following characteristics: all entities should be able to be represented figuratively in each of the semantic fields to which they belong. But the whole lexicon can not be represented by a figurative scripture; a symbolic system must be added. For example, BLISS describes concepts from a base of 26 elements and a law concatenation. If the lexicon is semantically structured, it is expected that the semantic indications should be used. Such information may be used as helps to word prediction in the building of the sentence. But what is the support of these predictions? Several methods are available:

- A frequency of occurrences of words from one or more previous words (n-grams).
- A calculation from semantic compatibility of weighted semes, that is, use of ontologies.

In a general use of writing, we are not persuaded that it is helpful to offer this assistance. The discussion returns to domain ontologies, where it can be useful, but in the case of a language that crosses the fields, associations of words in different semantic fields seem too uncontrollable. More, in this case, it becomes necessary to introduce feedbacks in order that the writer can verify that assisted written corresponds exactly with that (s)he has wanted to write.

Helping the writing process in the case of a pictographic writing

The organization of the lexicon should at the best match organization of entities of the world in our mind.

Therefore, the problem is to build the ontological categories that refer to the words of the lexicon, with the restriction that they do not represent all the different meanings of a word.

Building sentences: applicative grammar

How grammatical operations on words can be represented? It is clear that these operations are not the same for all syntactical categories: a name cannot be conjugated, and so on ... Obviously, types become necessary for a matching between operators and operands. One can wonder how far grammatical differentiation made by the syntactical categories denotes ontological differences. Syntactic categorizations are not universal and we can not find the same categories from one language to another. The large partition made by physics distinguishes what is stable and what evolves. This distinction is found for example in the work of Wilkins that distinguishes sorts, which can classify the world, and particles that can be considered as operations on sorts.

Here, we will consider names, that roughly represent stable, and verbs, used to represent changes.

In the pictographic scripture, places of grammar symbols in the sentence arise: are they placed before or after the word on which they operate? That is to ask how we think the operation on the name: prefixed or suffixed? It seems increasingly that we think about situations and that we know how to say them directly with the language, but for now the question remains.

When a userprocesses scripture in a new way, everything depends on his ability to use the GUI. To save changes of windows, operations for a syntactic category are placed on the same page as those of pictographic categories: passing on the pictogram of operation gives the result of the sentence in the lower window. For example, passing on the pictogram <PLURIEL> in a page of names affects morphology of the name with a mark of plural., preceded by an article indicating plural. Then this so pre-viewed operation can be selected.

The operations that include the names

We give here a summary of information contained in the lexicon, which can link a word to an image. Important information for the construction of sentences are:

the word, its syntactic category, a semantic element (style) for grammatical purpose, and the image that allows the selection of the word.

```
<element mot="moi" type="PRONOM" style="LOCUTEUR" image="je.gif"/>

<element mot="toi" type="PRONOM" image="tu.gif"/>

<element mot="petite_fille" type="NOM" style="FEMININ" image="petit_fille.gif"/>

<element mot="Mamie" type="NOM" style="FEMININ|SANSARTICLE"/>

<element mot="moustique" type="NOM" image="moustique.gif"/>
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<element mot="mouche" type="NOM" style="FEMININ"
image="mouche.gif"/>
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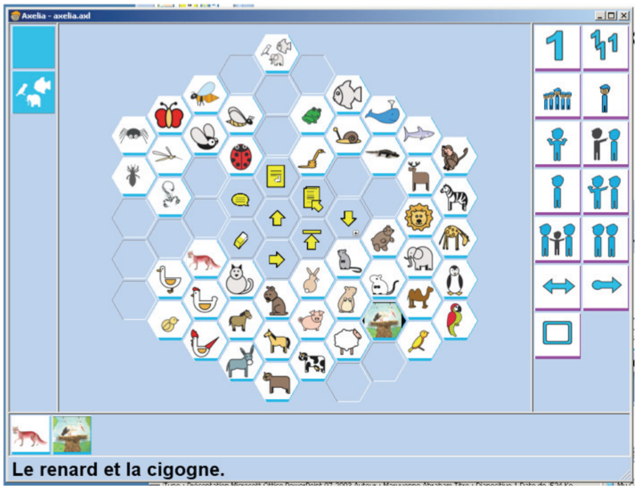


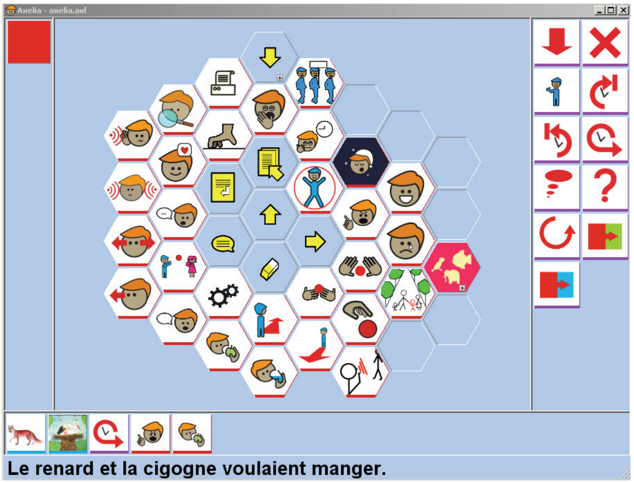
Le renard et la cigogne.

Figure 3: the names and their operations

The operations which focus on verbs

The lexicon of verbs is organized in the same way as the lexicon of names: the word, its syntactic category, and the image that allows the selection of the word.

```
<element mot="exécuter" type="VERBE"  image="executer.gif"/>
```



Le renard et la cigogne voulaient manger.

Figure 4 : the verbs and their operations

Now, the question of how to categorize verbs of the lexicon arises. We have shown [Abraham, 1995] that, given the verbal polysemy, it is not the words of the lexicon which are to be categorized, but the concepts held in semantic fields. Thus, micro-semantic fields are proposed in the windows giving access to the lexicon of verbs: for example, in Figure 4, the red pictogram gives access to verbs which specifically concerns animals, being understood as a means to find them easily. To rush is well represented as an action related to horses, but a person may, for example, rush in stretchers, even if the verb to rush is found in this specific page concerning animals.

Conclusion

Ontologies represent a referential organization of the world, which allows us to have a more or less shared independent knowledge of languages. It is the goal of WordNet, which organizes the words around synsets. Synsets are sets of synonyms build around a concept which is not clearly given. Such a project has an adequacy when it concerns names, but is not so relevant for adjectives, verbs, and prepositions.

Languages build patterns of the world, but the patterns are not similar from one language to another one. The role of language is to communicate meaning: from a shared knowledge of the world they have built, they allow to say something else than referential obviousness.

In the problem of disability that we seek to address, change writing and breaking up the act of writing by at least three stages (Thinking the situation, finding the words, applying the grammar) shows that it is at the level of the organization of syntactic then semantic domains of words of lexicon that ontologies are appropriate. In our problem, they give the user access to words through a best representation of the entity which is denoted by this word. Then the pictogram is only used as a new scripture of the word. It is no longer the reading of the series of images which are to be read. It is the interpretation of the text given by this new scripture which gives access to the situation described by the language.

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