NLP model and tools for detecting and interpreting metaphors in domain-specific corpora

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Abstract

The aim of this paper is to present how a user-centred lexical representation model, based on the theory of Interpretative Semantics, can be used for detecting and interpreting metaphors in domain specific corpora. We present here several tools useful for such tasks and discussing the results of an experiment.

Introduction

In this paper, we present NLP (Natural Language Processing) project addressing the interpretation process. This project, called "ISOMETA[1]", focuses on computer-assisted metaphor interpretation following a user-centred point of view. We propose a model for lexical representation as well as tools for validation on corpora.

In the first section, we give an overview of some previous approaches related to metaphor detection and interpretation in order to highlight the main concepts we deal with. We also introduce the theoretical background for knowledge representation and text interpretation sustaining our approach.

In the second section, we argue for user-centred lexical representations and we present our model for this purpose (called *Anadia*) as well as practical examples. This model enables automatic computing of customized help for interpretation by means of the isotopy concept. We detail how to produce such help when dealing with conventional metaphors.

In the third section, we present some of the tools implementing our main propositions. AnadiaBuilder is a user-friendly interface to build structured lexical representations. Complementary tools have been developed for corpus analysis, producing graphical representations for easy browsing through the results and customized help for interpretation.

In the last section, we present the results of an experiment on a domain-specific corpus. We study examples of a specific conventional metaphor: the stock market domain expressed with meteorological terms.

Finally, we discuss how to carry out an evaluation of our work. We also propose other applications of our model and tools. We conclude by pointing the main directions for further developments and the next steps for the "ISOMETA" project.

1 Framework

1.1 Metaphors in NLP

It is generally agreed that a metaphor involves two concepts: a source concept, related to the words used metaphorically, also called the vehicle of the metaphor, and a target concept, which is what the metaphor is used for and tries to describe, also called the tenor of the metaphor. If we consider the following example, first proposed by Wilks (1978), and still studied by Fass (1997):

(1) "My car drinks gasoline",

the source of the metaphor is *the action of drinking*, and the target may be described as *the use of gasoline by a car*.

The different NLP approaches for metaphor interpretation mainly depend on how the relation between the source and the target is viewed: as an analogy, as a novelty, or as an anomaly. In (Gentner, 1983; Falkenhainer et al., 1989), this relation is mostly viewed as an analogy. Thus, interpreting a metaphor requires deeply structured knowledge representations in order to trace back and describe the analogy between concepts. In (Indurkhya, 1992; Gineste et al, 1997), the relation between the source and the target is viewed as a novelty: it is not a pre-existing similarity but one created by the existence of the metaphor. Thus, interpreting it requires the dynamic selection and transfer of knowledge from the source domain to the target domain.

[1] "ISOMETA" stands for ISOtopy and METAphor.

Metaphor may also be viewed as a semantic anomaly. In example (1), there is an anomaly if one considers that "*drinking*" does not normally apply to physical objects such as cars. As shown by Martin (1992), metaphors are not always anomalies, and anomalies are not always metaphors. For instance, in:

(2) "McEnroe killed Connors" (ibid),

there is no anomaly, nonetheless "killed" may be viewed as metaphoric. Only contextual information can help for disambiguating the whole sentence. Fass (1997) proposes a method for discriminating semantic relations, which makes a clear distinction between metaphors and anomalies. This method makes it possible for multiple interpretations to coexist, as in example (2).

It is not necessary to focus on the relation between the source and the target to interpret metaphors. Kintsch (2000) shows how the meaning of a metaphor can be interpreted and represented by a multi-dimensional vector, exactly like other meanings in the Latent Semantic Analysis approach.
We also consider that metaphors require the same interpretation process as other meanings. We do not focus on the relation between the source and the target either. But in our approach, we use a symbolic representation in order to provide a novice user with easily understandable tools.

Lakoff and Johnson (1980) introduced the notion of conventional conceptual metaphor, based on the observation that, for some semantic domains, multiple terms from a common source domain may be used to describe metaphorically multiple corresponding concepts from a common target domain. In (Ferrari, 1997), such conventional metaphors are studied in the scope of domain specific corpora. For instance, he observed that stock market events are often described by meteorological terms in newspaper articles related to economics.

In our work, we look at conventional metaphors in order to use the pre-existent knowledge that the target domain may be partly structured as the source domain. We focus on the previous example, which we call "*economics is meteorology*".

Using limited and user-centred resources, we try to track down the analogy and the novelty points of view. In the next section, we present the linguistic basis of our approach.

1.2 Knowledge representation and text interpretation

The lexical representation and the analysis process we use are mainly inspired by continental structural linguistics (Greimas, 1966; Pottier, 1987) and especially by the linguistic theory developed by F. Rastier (1987): Interpretative Semantics. In this theory, the interpretation is considered as a description of semantic units located both in a linguistic unit (corpus, text, sentence...) and a situation. Interpretation involves an interpreter, along with his knowledge, his goals and his social relation[2] to these given linguistic units. Thus, the meaning of a word, for instance, is not a definition of this word, as could be found in a dictionary, but rather an explanation of its role in a given linguistic unit.
A lexical content is described in terms of meaning components, themselves described in terms of semantic features called *semes*. For example, the lexical item "depression" can be related to a 'meteorological phenomenon' or a 'mental state', and the meaning component 'meteorological phenomenon' can be represented with the following *semes*: /area/, /low pressure/, /bad weather/… Such a description is called a componential representation.

Semes depend both on the user and on the task. They are potential meaning features, relevant only in specific contexts. The notion of *isotopy*, introduced by Greimas (1966), characterizes these contexts. An isotopy is the recurrence of one *seme* in a linguistic unit. For instance, in this paper, one may notice at least two main isotopies related to 'computer science' and 'linguistics', supported by many different lexical items.

In our work, we focus on lexical items from two domains, meteorology and stock market, in order to describe the underlying conventional metaphor. In the next section, we present Anadia, the model we have previously developed for such lexical representations, and show how to use it for metaphor processing.

2 A model for lexical representation

2.1 Main principles

The main principles of our model have been described in details by Beust (1998) and Nicolle et al. (2002). Anadia is a model of lexical categorization based on both componential and

[2] We are talking about the relation to linguistic units through social role. For instance, a juridical text is differently interpreted by a lawyer and by common people.

differential representation. The differential paradigm states that a lexical content can be described by opposing it to others through structural relations, following the notion of "linguistic value" proposed by Saussure (1915). The *Anadia* model allows a user to produce descriptions of meaning components by the way of *semes*, which are the componential part of the representation. Rather than classical componential representations, *semes* are represented by a set of opposite features. This is the basis of the differential part of the representation. For example, "*depression*" can be described as the combination of the *semes* [Zone] and [Pressure] respectively corresponding to the opposite features "area vs. line" and "low vs. high". The activated features for "*depression*" are area and low. These *semes* also allow a semantic representation of the lexical item "*anticyclone*" described by the activated features area and high.

Lexical items representations are therefore made from the combination of *semes*. In this way, our model allows its user to build tables where lexical items can be described in terms of differences and common points, as shown in Figure 1.

Pressure zone	Zone	Pressure
anticyclone	area	high
tropical wave, easterly wave	line	low
depression, cyclone	area	low
	line	high

Figure 1. Example of an Anadia table describing some pressure zones[3].

In Figure 1, the combination of the *semes* [Zone] and [Pressure] gives rise to four table rows in which lexical items can take place. When there are several lexical items in the same row, it implies that their semantic representations are not considered as different in this table (in another one, they could be differentiated). It is the case for "tropical wave" and "easterly wave" in the example. A row can stay empty if we do not know any lexical item corresponding to a certain combination of features. It is the case for the combination of 'line' and 'high' in the example. A row can also be filled in later if we find a corresponding lexical item (for instance, by the way of a corpus study).

Several tables can be used to describe a specific semantic domain. In such a set of tables, a table can be linked to a row in another table by a subcategorization relation (Figure 2).

Domain objects	**Role**
stocks, currency (...)	playing a part
charts, ratio, stock indices, curves (...)	studying, analysing

Stock Indices	**Geographical Zone**
CAC, CAC40	France
Dow Jones, Nasdaq	USA
Nikkei	Japan
Dax	Germany
Footsie	UK

Figure 2. Extract from a set of tables for the stock market domain. The second row of the Domain objects table is linked to the Stock indices table by a relation of subcategorization.

For many reasons (choice of *semes*, content of rows, subcategorization relations) tables represent the points of view of the user for a given task. Anadia is a user-centred model and the lexical representations built with the model are not supposed to be either universal or exhaustive. Tables can be modified and updated at any time, depending on the results obtained from the analysis process.

Anadia tables allow proposing an analysis process based on the concept of isotopy. As shown by Tanguy (1997), isotopy can be seen as an easy and understandable way of expressing themes in linguistic units. Therefore, the interpretation process consists in finding isotopies in linguistic units.

(3) *During the three days immediately proceeding* ***depression*** *formation, anomalous moisture transforms from a pattern associated with a* ***tropical wave*** *transversing the open Atlantic Ocean ... (http://ams.confex.com/ams/25HURR/25HURR/abstracts/35268.htm)*

[3] The examples have been translated for this paper.

In example (3), using the representation of Figure 1, we notice that "tropical wave" and "depression" are described with the same *semes*: [Zone] and [Pressure]. These two recurring *semes* involve two isotopies that contribute to the meaning to the sentence. The recurring features also show that the sentence deals with pressure zones of different type : one corresponding to a 'line' of 'low' pressure and one to a 'area' of ''low' pressure.

2.2 Using the model for metaphor processing

The *Anadia* model was not originally designed for metaphor processing. The latter is just a specific task for which the model can be used. In order to study how the model can effectively be applied to metaphor processing, and what adjustments are to be made, we focus on the specific conventional metaphor: *"economics is meteorology"*.

The model enables us to represent our lexical knowledge concerning the source and the target domains involved in this specific metaphor. Let us work on the assumption that one set of tables, set S, describes the lexical items of the source domain, *meteorology*, and a second one, set T, is dedicated to the target domain, *stock market*.

At this point, the Anadia model enables us to use a single lexical item in multiple sets of tables. For instance, it is possible to represent "*barometer"* both in set S and in set T. In set S because it is a common term of meteorology, and in set T because we have noticed in newspaper articles that it is sometimes used in phrases such as "*stock market barometer*", suggesting some economical tools for measures or predictions.

This possibility becomes a problem when dealing with metaphors. If we want to use the model to detect the metaphorical use of *"barometer"* in phrases such as *"stock market barometer"*, we must not represent it in set T. Moreover, lexical items of set T must not be formed with words that can be considered as lexical items of set S. This is a first adjustment, or constraint, added to the Anadia original model: when building sets of tables for metaphor processing, it is necessary not to use words from a source domain in a set of tables for a target domain.

Following this rule, *"barometer"* is now banished from the lexical items of set T. The reason for this is that when computing isotopies, the source *semes* are required to spot a metaphorical use. If *"barometer"* were in the two sets, S and T, its metaphorical use in *"stock market barometer"* would be ignored because an isotopy of words from set T would only hide the existence of *semes* from the source domain. It is important to notice that such a representation must not be considered as "wrong" and would not lead to misinterpretation. It would simply reflect the conventional aspect of the metaphor, which itself would be part of the knowledge of the user who would include "*barometer"* in the lexicon related to *"stock market"*.

Assuming that S and T are now built according to that constraint, let us see how it is possible to spot a metaphor, and to what extent the lexical representation can produce guidance for its interpretation. The whole point is to detect an isotopy involving words from both the source and the target domain. On the one hand, with the Anadia model, isotopies are based on *semes* shared by lexical items involved in a single linguistic unit. On the other hand, previous works on conceptual metaphors have shown the existence of underlying structure analogies between the source and the target domains. It then stands to reason that the solution is to use some *semes* which are shared by lexical items from the two sets of tables, and which represent the structure analogy between the two domains. For example, if we use the *seme* [Role = studying, analysing vs playing a part] to describe "*barometer*" from the meteorology domain and "*stock exchange*" from the stock market domain, it then becomes possible to spot and produce guidance for interpreting the following metaphor :

(4) a- "the Dow Jones is a stock exchange barometer".

The *seme* [Role] is here shared by two lexical items: *"barometer"* from the source domain and *"Dow Jones"* from the target domain. The fact that the lexical items involved belong to different domains is characteristic of a metaphorical use. The shared *seme*, creating an isotopy, is a first step for guiding the interpretation process. We shall discuss these points further in the following sections.

At the moment, we can consider the use of shared *semes* as a second adjustment or constraint added to the model when processing metaphors. If sets S and T are built according to the two constraints presented in this section, it is not only possible to spot metaphors involving the lexical items initially used to organize the two sets, but also to process some of their extensions. Actually, when building the set of tables concerning *meteorology*, the user will probably consider lexical items such as "*thermometer*", "*mercury*", and propose to use the same *seme* [Role] to describe them. It will then be possible to process the following examples:

(4) b- "the Dow Jones is a stock exchange thermometer"

(4) c- “the Dow Jones is the New York stock exchange mercury”

even though the sets of tables were not originally designed for these specific metaphors.

The next section presents tools developed in order to validate our model on corpus.

3 Tools

The tools we created for our experiments are freely available for research purposes. They have been implemented with platform-independent languages (Java, XML and XSL). They can be used for different kinds of tasks including figurative language analysis (as shown in this paper) or for instance document retrieval (as shown in (Perlerin, 2001)).

3.1 AnadiaBuilder: a tool for building Anadia lexical representations

AnadiaBuilder is software enabling to build lexical representations following the Anadia model (Nicolle et Al., 2002). The created data is stored in XML format. Via a user-friendly graphical interface, the user can build sets of tables according to the current task. The interface contains five main interactive panels:

(A) The first one enables the user to create the *semes* he finds relevant for the representation. The user chooses the related sets of opposed features and an explicit name for each *seme*.

(B) The second one makes it possible to create tables made from the combination of semes (Figure 3). The user chooses the semes and the machine computes the combinations and automatically builds the table. The user fills in the cells (on the left-hand part of the table) corresponding to a given set of features from different semes with relevant lexical items.

(C) The third one displays a graphical representation of a table (called “topique” in French) showing the differences and the semantic proximity between lexical items by means of annotated links (Figure 3).

(D) The fourth one creates the relations between tables. It also makes it possible to see the whole set of tables through a schematic representation where only table names are displayed (Figure 4). In this panel, the user can allocate a colour to each table, which is useful for further corpus analysis.

(E) The last one is linked to the MAHTLEX lexical database, developed at the University of Toulouse[4]. For each lexical item, the computer proposes a set of inflections or enables the user to build the corresponding set of inflections by himself. Inflections will be used to match occurrences of lexical items in texts.

At step (B), when building a table, if the user estimates that he can fill in several cells with the same lexical item, he must correct his proposals. This fact can happen because of two reasons. The chosen *semes* are not mutually exclusive, or the features of at least one *seme* are not mutually exclusive. The building contraints of the Anadia model are discussed by Beust (1998). Perlerin et Beust (2002) have undertaken an experiment with novice users. The results have shown that building a set of tables following the Anadia constraints is accessible to novice users. Such results may have to be moderated when dealing with a linguistic phenomenon such as metaphor.

[4]http://www.irit.fr/ACTIVITES/EQ_IHMPT/ress_ling.v1/accueil01.php

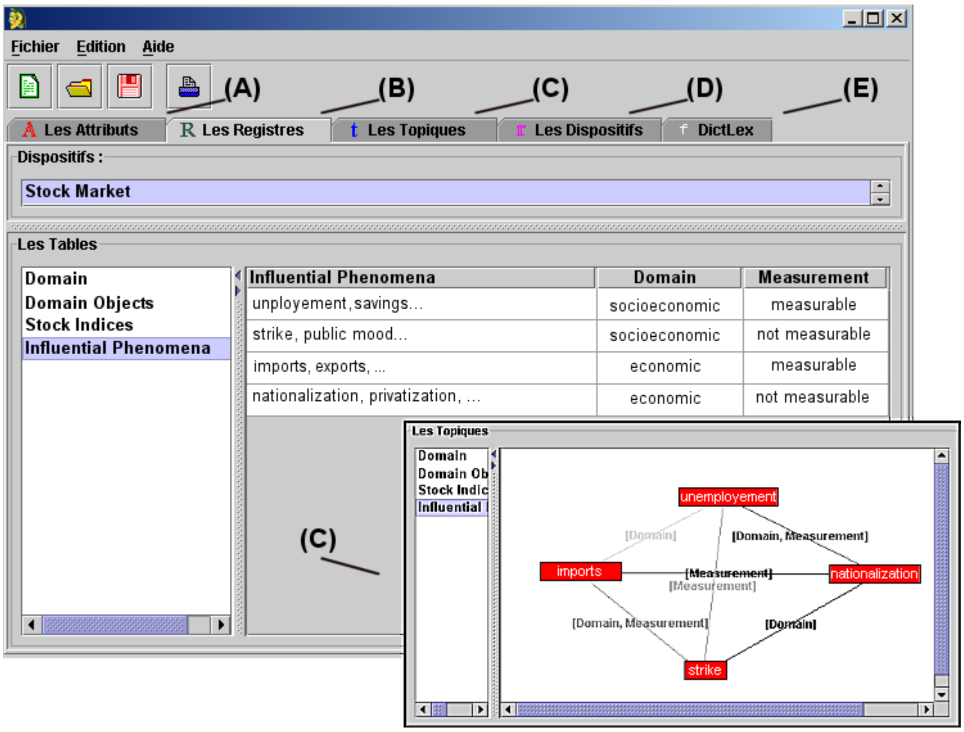

Figure 3. AnadiaBuilder: tables building panel and corresponding "topique" from the "topique" panel (extract of the screenshot).

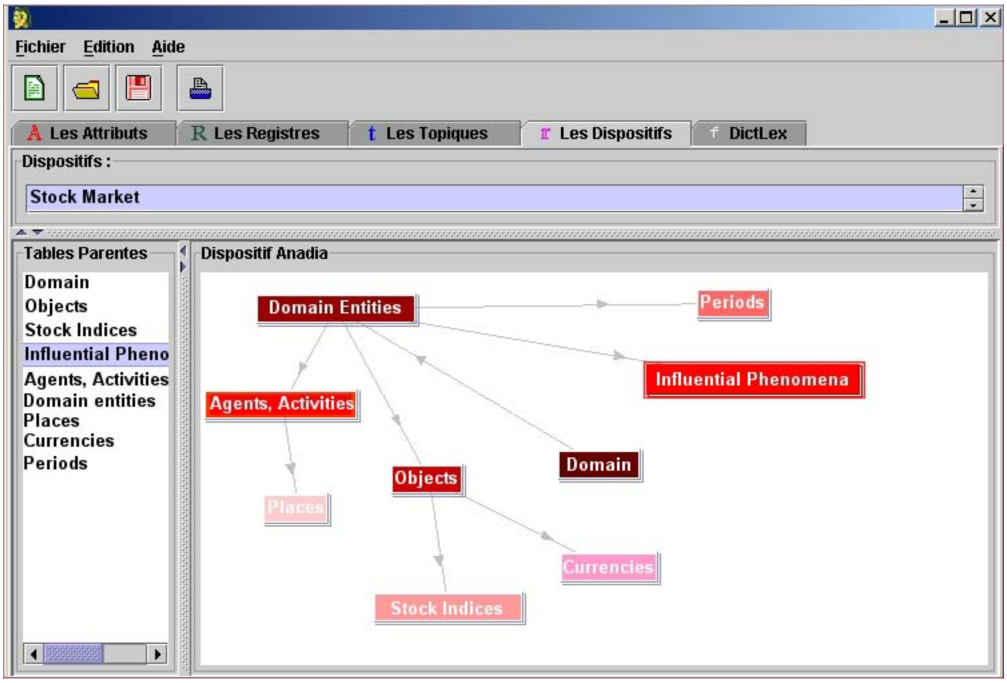

Figure 4. AnadiaBuilder: set of tables representation related to the stock market domain.

Each set of *semes*, each set of tables or inflections dictionary can be saved independently and reused in different experiments. In particular, the sets of tables can be used for corpus analysis. Results are then produced as an annotated version of the corpus. Several tools help us to browse through the resulting corpus, mainly by the use of colours and charts.

3.2. Corpus analysis tools

During the automatic part of the corpus analysis, all the possible occurrences of lexical items from the sets of tables are located in the texts. A first tool builds a graphical representation of each text in the corpus[5], as shown in Figure 5. For one text, each table is represented by one bar inheriting its colour. Each bar is proportional to the number of matched lexical items from the table. In our experiment on the metaphor "*economics is meteorology*", the purpose of this graphical representation is to provide the user with a quick way to track down articles where the source domain is evoked. A single HTML page contains all the charts along with hyperlinks to the related texts (Figure 5).

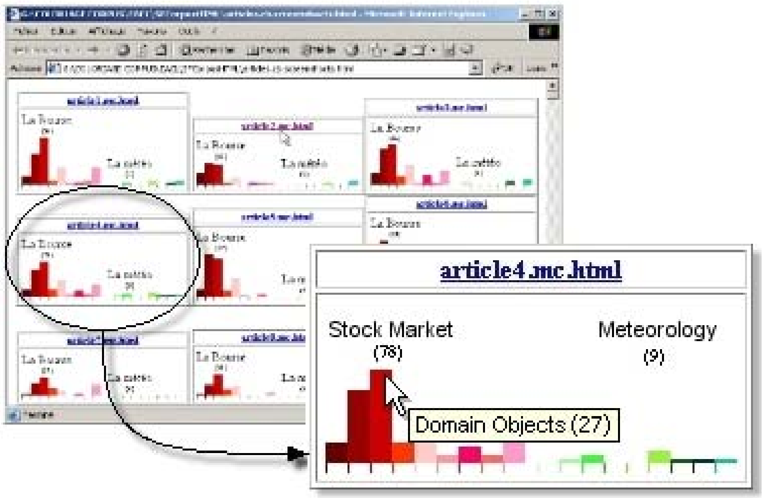

Figure 5. Graphical representations of the outputs:
moving the mouse over a bar shows the corresponding table name
and matches the number of lexical items.

A second tool transforms the XML version of each text into an HTML version, as shown in Figure 6. In the HTML version, the matched lexical items are in the same colour as the corresponding table. This provides the user with an easy means to find the precise location of the lexical items he is interested in.

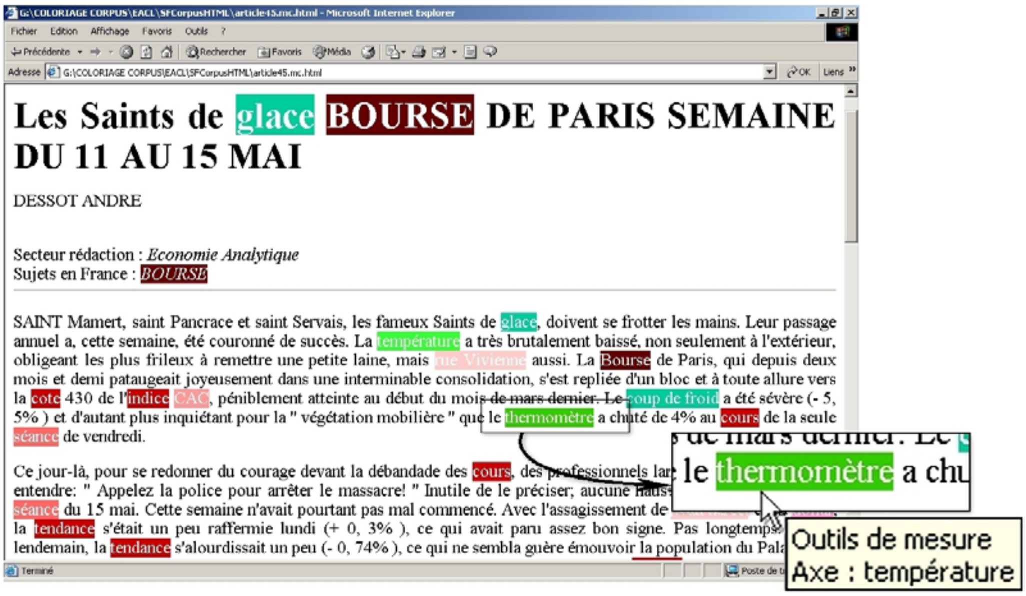

Figure 6. A coloured article.
Moving the mouse over a coloured lexical item shows the corresponding
table name and the corresponding set of *semes*/features.

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[5] In our experiments, the article appeared to be a relevant unit to build the charts. The level of this linguitic unit can be changed.

The next session presents some results of an experiment realised on a journalistic corpus.

4 First results

Our work has been validated through a corpus experiment. The corpus is constituted of about 600 articles from the French newspaper “Le Monde”, addressing economics and stock market (around 450,000 words) between 1987 and 1989. This corpus, already studied by Ferrari (1997), contains numerous examples of the conventional metaphor “economics is meteorology”. It also contains lexical items from the meteorology domain that are not used in a figurative way.

For our experiment, the sets of tables have been designed with nine shared *semes*. These *semes* reflect our own view of the conceptual metaphor. Specialists of any of the two domains would probably have designed the sets of tables in a much different way. Our point of view reflects our knowledge of the underlying analogy between the two domains. In the following, we discuss two different examples in order to show how the analogy and novelty points of view can be retrieved with our proposals.

> *(5) Le Dow Jones par exemple, le thermomètre de la Bourse de New York, qui avait chuté de 508 points …*[6] - Article n°126 – Paragraph 1

In example (5), three lexical items from the sets of tables were matched (therefore coloured) by the analysis process. “Dow Jones” appears in the “Stock Indices” table of the stock market domain (see Figure 9). “thermomètre” (*thermometer*) appears in the “Measuring Instruments” table of the meteorology domain (see Figure 8).

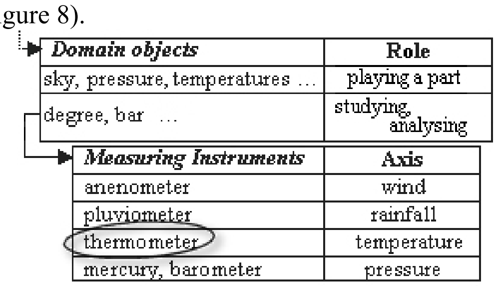

Figure 8. Extract of the meteorology *Anadia* set of tables.

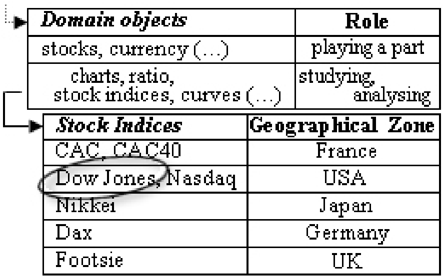

Figure 9. Extract of the stock market *Anadia* set of tables.

Following these representations of the two domains, an isotopy involves the shared inherited *seme* [Role] and the value ‘studying, analysing’ can be found thanks to the first two coloured lexical items. One can then conclude in favour of a metaphorical use and propose the following interpretation: “thermomètre” (*thermometer*) is used in the same way as “graphics”, “ratio”... i.e. to suggest an object for analysis and study in the stock market domain. The lexical item could be replaced (more or less efficiently) by others from the “Measuring Instruments” table.

> *(6) Ce krach était dû (...) à la chute vertigineuse et incontrôlée du dollar, signe que la tempête affecte dorénavant les marchés financiers.*[7] - Article n°153 – Paragraph 3

In example (6), the lexical items “krach” (*crash*) and “tempête” (*storm*) appear in the following tables (Figure 10 and Figure 11).

[6] Literal translation: *The **Dow Jones**, for instance, the **thermometer** of Wall Street, which had fallen 508 points …*

[7] Literal translation: *This **crash** was due (...) to the vertiginous and uncontrolled fall of the **dollar**, sign that the **storm** will henceforth affect the financial markets.*

Dynamic phenomena	Direction	Connotation
depreciation, devaluation, crash, to devalue	down	bad
rise in prices, inflation	up	not connoted
drop in prices, deflation	down	not connoted

Figure 10. Extract from the stock market *Anadia* set of tables (the table has been truncated).

Dynamic phenomena	Direction	Connotation	Axis
frost, to freeze	down	bad	temperature
bad weather (...)	up	bad	weather
lull (...)	down	good	weather

Bad weather	Strengh
gust, storm, gale, (...)	violent
cyclone, typhon, (...)	fierce

Figure 11. Extract from the meteorology *Anadia* set of tables (the tables have been truncated).

The isotopy found in this sentence (example 6) is based on two different *semes*. The first *seme* involved is [Connotation] (inherited for “storm”) with the same activated value ‘bad’. The second one is [Direction] with two different activated values: ‘down’ for “krach” and ‘up’ for “tempête”. Example (3) makes it possible to conclude in favour of a metaphorical use. First, due to the activated values, the *seme* [Direction] is less relevant than the other one, [Connotation]. Moreover the *seme* [Axis] is exclusively used in the meteorological domain and is not involved in any isotopy. We propose therefore to consider it as “irrelevant” in the context. The *seme* [Strength] does not take part in an isotopy either; but, unlike [Axis], it can be shared between several lexical domains. It seems to us that we can therefore consider it as relevant in this context. This illustrates how novelty is dealt with in our approach. Finally, we propose the following help for interpretation: “tempête” (*storm*) is used to evoke a not only bad but also violent dynamic phenomenon in the stock market domain.

Numerous examples of sentences where the sets of tables enable to conclude in favour of metaphorical uses have been discovered in the corpus thanks to our tools. The two sets of tables have been modified several times depending on the results obtained from the analysis process. Those results are the fisrt step of the “ISOMETA” project validating our approach and our tools.

Conclusion and further works

This paper has presented a user-centred lexical representation model and its use to produce help for metaphor interpretation. There is no need to be an expert in a given domain to describe it by means of this user-centred model. Nevertheless, metaphor interpretation is a linguistic task. Thus, a description for a study on a conceptual metaphor, such as the one we have presented in this paper, requires a certain familiarity with linguistic sciences. The user must indeed be able to describe how he appreciates the analogy between the source domain and the target domain by the use of shared *semes*.

Though we have presented the use of the Anadia model for a very specific task, we have already argued for its use in many applications, such as domain-specific corpus browsing or document retrieval, as shown in (Nicolle et al. 2002). We hope the same applies to the tools developed for the “ISOMETA” project.

An experiment on domain-specific corpus has validated our method. Actually, producing customized help for metaphor interpretation appears to be possible. However, this result must be evaluated, both quantitatively and qualitatively. Nevertheless, such an evaluation is not easy to carry out. On the one hand, the user-centred aspect of the model implies that the evaluation process should be user-centred too. On the other hand, this evaluation requires an annotated corpus. Such a reference corpus does not exist yet and seems difficult to produce.

In order to start the evaluation, our further works will concern other examples of conceptual metaphors, as well as other domain-specific corpora for their study and the automatic processing of isotopies. We also plan to use our model for metaphor and paraphrase in automatic text generation.

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