Argument Mining: the Bottleneck of Knowledge and Language Resources

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Abstract

Given a controversial issue, argument mining from natural language texts (news papers, and any form of text on the Internet) is extremely challenging: domain knowledge is often required together with appropriate forms of inferences to identify arguments. This contribution explores the types of knowledge that are required and how they can be paired with reasoning schemes, language processing and language resources to accurately mine arguments. We show via corpus analysis that the Generative Lexicon, enhanced in different manners and viewed as both a lexicon and a domain knowledge representation, is a relevant approach. In this paper, corpus annotation for argument mining is first developed, then we show how the generative lexicon approach must be adapted and how it can be paired with language processing patterns to extract and specify the nature of arguments. Our approach to argument mining is thus **knowledge driven**

Keywords: Argument mining, Knowledge representation, Generative lexicon

1. Aims and Challenges of Argument Mining

One of the main goals of argumentation mining is, given a controversial issue, to identify in various texts the arguments for or against that issue. These related arguments act as supports or attacks of the issue, depending on their orientation. Arguments may also attack or support the other arguments which support or attack that controversial issue in order to cancel out or reinforce their impact. An argumentation is represented by a graph of supports and attacks. Arguments are difficult to identify and to characterize, in particular when they are not adjacent to the controversial issue, possibly not in the same text. Arguments are often standard natural language statements which get the status of arguments because of the specific relations they have with a controversial issue. For example, the statement from the Indian Times:
(a) *we now see long lines of young girls with school bags along the roads*
could be just factual, but given the controversial issue:
(b) *the situation of women has improved in India*,
then, statement (a) becomes an argument supporting (b), which is then interpreted as a controversial issue which can then be supported or attacked. Except in specific contexts, and for certain forms of arguments (e.g. warnings, threats, advice, requirements), most arguments do not have any specific linguistic mark that would allow to identify their relation to a controversial issue. Furthermore, it is difficult to identify whether a statement is a support or an attack of a controversial issue, and what it precisely attacks or supports. In the above example, *school bags* means education: it is a means to improve women's condition because it leads to jobs and more independence. It does not talk about anything else concerning women's conditions. Relating a controversial issue with arguments requires knowledge, lexical semantics data, and appropriate inferential patterns. It is therefore much more complex in terms of semantics and reasoning than e.g. standard opinion analysis based on evaluative expressions analysis.

Argument mining is an emerging research area with new challenges that require the combination of linguistic analysis and language processing with artificial intelligence. Argument mining is at the moment applied mainly to written texts, e.g. (Mochales Palau et ali.., 2009), (Kirschner et ali., 2015), opinion analysis, e.g. (Villalba et al., 2012) dialogue analysis, e.g. (Budzynska et ali., 2014), (Swanson et ali., 2015). The analysis of argument mining techniques from annotated structures in analyzed in e.g. (Peldszus et al. 2016). Annotated corpora are being made available, such as the AIFDB dialog corpora at Dundee university or corpora developed by (Walker et al., 2012). These corpora are very useful to identify argumentative discourse units (ADUs), linguistic cues, (Nguyen et al., 2015), and argumentation strategies, in a more concrete way than abstract argumentation schemes, as shown in e.g. (Feng et al., 2011). Finally, reasoning aspects related to argumentation analysis are developed in e.g. (Fiedler et al., 2007) and (Winterstein, 2012) from a formal semantics perspective.

The goal of argument mining is, given a controversial issue, to identify in a set of texts of various origins, statements which can be interpreted as supports or attacks to that issue. In opinion analysis, the benefits are not only to identify the customer satisfaction level, but also to characterize why customers are happy or unhappy. Abstracting over arguments allows to construct summaries and to define customer value systems (e.g. low fares are preferred to localization or quality of welcome for some categories of hotel customers). Argument mining from full natural language texts is extremely challenging: given a controversial issue, the identification of the relations between arguments and that issue is often more complex than just the bipolar support or attack view. For example, given the issue *Vaccination against Ebola is necessary* and the argument: *There are almost no cases of Ebola in Europe*: is this argument a support, an attack or something else ? Identifying the **conceptual link** between a controversial issue and an argument is of much importance to have a clear analysis of the role of an argument. In this example, the attack comes from the fact that there is no contamination in Europe. Our approach to argument mining is therefore **knowledge driven**.

2. Research Questions, Hypothesis and Foundations

This paper addresses the following challenges:

- The identification of the forms of knowledge and inferences required to identify arguments in texts,
- The identification of the linguistic cues that contribute to identify arguments in texts, in conjunction with knowledge and inference,
- The definition of a model that accommodates both knowledge and linguistic data,
- The identification of relatedness factors between a controversial issue and a statement, in particular which aspects or facets of the issue are attacked or supported,
- The identification of the argumentative relations between an issue and an argument: supports, attacks, various types of causality, concessions and supports, strength of the argument and its persuasion effect(s),

Our approach is organized as follows:
(1) The words in the controversial issue originate lexical and conceptual knowledge structures, where the main concepts in the issue form the root of the structure,
(2) Language patterns dedicated to argument analysis are associated to these knowledge structures, similarly to the procedural attachment techniques developed for frames and scripts. Argument mining is thus knowledge driven,
(3) These patterns allow to identify the kernel of the argument. They are associated with discourse analysis rules that recognize additional information frequently associated with these kernels that elaborate, justify or constrain them.
(4) Given our observations (reported below) the Qualia structure of the Generative lexicon (GL) is investigated as an appropriate formalism to represent both conceptual and lexical knowledge for argument mining. We show that the Qualia structure needs to be structured and improved for this task. A controversial issue then defines a network of Qualias, connected via their various roles.
(5) To each concept in the Qualia are associated lexical terms and language patterns designed to identify arguments.
(6) The features of an argument (polarity, strength, facets of the issue concerned, etc.) are computed compositionally from Qualia structures and dedicated inferences.
In this paper, to motivate this approach, we first develop a corpus analysis to characterize these challenges, outlining the types of knowledge required to extract and characterize arguments. We then briefly show how the Qualia structure can be enhanced for the purpose of argument mining. Finally we show via examples how language patterns are associated with Qualia to extract arguments. This paper is essentially a linguistic and knowledge modeling contribution.
An important point observed in our corpora is that argument kernels are not so diverse for a given issue. The diversity and the power of arguments comes from the discourse structures they are associated with, that elaborate, justify, illustrate or constrain them. These structures are identified using our TextCoop discourse analysis platform.

3. Corpus Construction and Analysis

3.1. Corpus construction

To explore and characterize the forms of knowledge that are required to develop argument mining in texts, we constructed and annotated four corpora based on four independent controversial issues. These corpora are relatively small, they are designed to explore the problem, and to elaborate a model, not to design a comprehensive argument mining system. The text fragments which are investigated are extracts from various sources where these issues are discussed, in particular: newspaper articles and blogs from associations. These are documents accessible to a large public, with no professional consideration. Language is essentially French (glosses are given is paper); some English texts have also been analyzed.
For this experiment, we considered the four following issues, which involve very different types of arguments, forms of knowledge (concrete or relatively abstract) and reasoning schemes, and language realizations (lexical, discourse). The issues are the following:
(1) Ebola vaccination is necessary,
(2) Women's condition has improved in India,
(3) The development of nuclear plants is necessary,
(4) Organic agriculture is the future.
For each of these issues, the corpus constructed and the different arguments found (eliminating duplicates or closely related ones) are:

Issue	Corpus size (short texts)	nb. of annotated arguments (no overlap)
(1)	16 texts, 8300 words	50
(2)	9 texts, 4600 words	24
(3)	7 texts, 5800 words	31
(4)	19 texts, 5800 words	17
Total	51 texts, 24500 words	122

Table 1. Corpus typology

The texts mentioned above are extracts of larger texts where the non argumentative sections have been eliminated. A text extract is about 500 words long, i.e. about one page. This corpus analysis shows that although texts are often rich in arguments, their diversity is not very large, since e.g. a maximum of 50 different arguments have been found for issue (1) and much less for the others. There is quite a high overlap rate, which is not very informative since authors frequently copy each others.

3.2. Annotation parameters

Arguments seldom come in isolation, as independent statements. They are often embedded into a context that indicates e.g. circumstances, restrictions, concessions, comparisons, purposes, and various forms of elaborations. In terms of language realization, arguments and their related context may be included into a single sentence via coordination or subordination or may be realized as separate sentences. In both cases, the relations between these different elements are realized by means of conjunctions, connectors, various forms of references and punctuation. We call such a form an **argument compound** (Saint-Dizier et al., 2014). The claim, behind this term, is that the elements in a compound

form a single, possibly complex, unit, which must be considered as a whole from a conceptual and argumentative point of view.
An argument kernel and its context (the argument compound) are tagged between XML <argument> tags with attributes. In the compound, the argument kernel is tagged <main arg>. Discourse structures within the compound are annotated using the tags defined in our TextCoop platform (Saint-Dizier, 2012). Annotations are relatively informal at this exploratory stage. Attributes in the main argument tag characterize the knowledge dimensions that are required for humans to analyze the arguments, these include:

1. the **text span involved** in the compound, which ranges from a few words to a paragraph. Arguments are numbered for referencing aspects,

2. the **polarity of the argument** w.r.t. the issue has one of the following values: support, concession (argumentative concession is a weak support), contrast (a weak attack), and attack. There is a kind of continuum between these values, and it is sometimes a matter of context and personal evaluation to make a decision,

3. the **conceptual relation with the issue**, which informally describes why it is an attack or a support,

4. the **knowledge involved**, when appropriate, to identify the argument: list of the main concepts used, informally described,

5. the **strength of the argument**, which is based on the linguistic marks in the text fragment. Some justifications can be included. In our view, persuasion is differentiated from strength: persuasion is a pragmatic notion that depends on context more than on pure linguistic marks.

An argument for issue (1) is the following:
<argument nb= 1,
polarity= concession ,
relationToIssue= limited proofs of efficiency and safety of vaccination,
conceptsInvolved= efficiency measure, safety measures, test and evaluation methods,
strength= moderate (relative) >
<concession> Even if the vaccine seems 100% efficient and without any side effects on the tested population, < /concession>
<main arg> it is necessary to wait for more conclusive data before making large vaccination campaigns < /main arg>
<elaboration> The national authority of Guinea has approved the continuation of the tests on targeted populations.</elaboration>
< /argument>.
The <main arg> tag identifies the argument kernel, that is modified by discourse structures realized either before of after the kernel. This simple example shows the type of text that is annotated and the nature of the concepts which are at stake. This example shows that the facet of the concept vaccine that is invoked is not the necessity of the vaccine but the need of some care (while other arguments, in contrast, develop costs, political or ethical aspects).
At this stage, the way these concepts are linguistically realized is not tagged. This is developed in section 5, where our method for argument mining driven by knowledge is developed.

3.3. Main characteristics of the corpus

From our manual analysis, the following argument polarities for the four controversial issues above are observed:

Attacks	Supports	Concessions	Contrasts	Ambiguous
51	32	17	18	4

Table 2. Polarity distribution

The corpus shows a tendency to argue against an issue rather than to support it (attacks and contrasts = 57%, supports and concessions = 40%). The need of knowledge to identify the relation between the issue and the argument and the number of different concepts involved is summarized as follows:

Issue	need of knowledge (nb of cases + rate)	total number of concepts involved (estimate)
(1)	44 (88%)	54
(2)	18 (75%)	23
(3)	18 (58%)	19
(4)	15 (88%)	25
Total	95 (78%)	121

Table 3. Evidence for Knowledge

These figures, although limited to a small experiment, show that for about 78% of the arguments found related to one of the 4 issues investigated, some form of knowledge is involved to establish an argumentative relation between a statement and an issue. An important result is that the number of concepts involved is not very large: 122 concepts for 95 arguments over 4 domains. Even if the notion of concept remains somewhat vague, these results are nevertheless interesting. The number of arguments found per controversial issue in our experiment shows a relatively good coverage of the domain. This is an important observation for the scalability issue since this means that the necessary concepts remain limited.

4. Analysis of the types of knowledge involved in argument identification

In this section, the different facets of the knowledge that is required for argument mining are explored. We show that a revised version of the Generative Lexicon (GL) (Pustejovsky 1996) is an adequate representation that merges lexical aspects with knowledge. The experiments have been realized on the four corpora; the examples given here are extracts from case (1) (Ebola vaccination), the other corpora, although quite different from a linguistic point of view, induce similar types of observations.
Let us now illustrate the various concepts used in argument kernels and how they lead to the identification of their polarity with the use of knowledge.

4.1. Main concepts used in argument kernels

Here are samples of arguments organized by polarity:
Supports:
- efficiency of vaccine very good, 100% protection,
- avoids or reduces dissemination of disease,
- limited side-effects,
- no medical alternative to vaccine,
- useful to avoid crimes and bio-terrorism,
- vaccine production possible,
- severity of disease (high number of deaths) .

Attacks:
- Limited number of cases and deaths compared to other diseases,
- Limited risk of contamination, ignorance of contamination forms,
- Can be controlled by other medical treatments,
- Very high production costs, too expensive for poor countries,
- Toxicity and high side-effects,
- Excessive government reaction: isolation of populations, racism.

Concessions or Contrasts:
- Some side-effects,
- High production and development costs,
- Getting competent staff + P4 lab difficult,
- Difficult to demonstrate efficiency, not enough data,
- Vaccine not yet available,
- Ethical and freedom problems,
- Results around 90% (performances), therefore not fully reliable.

etc.

4.2. Expression of concepts in argument kernels

The above arguments are expressed in various ways:

- **use of evaluative expressions:** arguments based on concepts such as side-effects, efficiency, or costs, independently of their polarity (support or attack), can linguistically be realized by means of evaluative expressions: *side effects are limited, very high. Vaccine development is very expensive*, etc. The general form is based on the attribute-value format, similarly to opinion statements in opinion analysis.

- **use of comparatives:** arguments based on concepts such as severity of the disease, can be linguistically realized by means of comparisons: *number of sick people much smaller than with Malaria. Disease is better controlled by other treatments such as patient hydration*. In this case, the orientation must be evaluated from the different components of the comparison.

- **use of facts related to properties of the main concept(s) of the issue:** that support or contradict the issue, directly or in an elliptical way: *Vaccine is not yet available. There is no risk of dissemination. Contamination can be easily controlled via simple hygiene rules.*, *not fully tested*, etc.

- **use of facts related to the consequences, purposes, uses or goals** of the issue, which are positive or which must be avoided: *vaccine prevents bio-terrorism. Vaccination allows to develop a protection belt for other populations*.

4.3. From concepts to knowledge representation

Let us now investigate how concepts can be structured and characterized to allow for an efficient argument mining process. Given any statement in a text, the challenges are (1) to identify the potential relatedness of this statement with the issue, then, (2) if related, which aspect(s) of the issue it deals with, and finally, (3) the orientation or polarity of the statement.

In corpus (1), the concept *vaccine* is the root of the system since it is the main term of the issue, on which the modal *necessary* is applied. The issue may be elliptical since vaccine may also stand for the event *vaccination*. The facets of this concept can be organized as follows:
- The parts of a vaccine are rather simple: the *adjuvant* and the active principle.
- Concerning its super types, a vaccine is a kind of medicine.
- The most central aspects of the concept vaccine w.r.t. argument mining are:
(1) its purposes, goals and consequences,
(2) how it is used,
(3) how it is created, tested and sold.

A number of these features may be inherited from the concept *medicine*, super-type of *vaccine*. Another central concept of the controversial issue is the disease *Ebola* whose effects and consequences should be controlled by the vaccine (section 5.2).

Let us consider a few concepts used to identify the arguments presented in section 4.1 and investigate how they are related to the concepts of vaccine and Ebola, and their super-types:
- The concepts of *side-effect* and *toxicity* are consequences of using a medicine or, from a different perspective they are properties of (some) medicines.
- The concept of *contamination* is related to one of the purposes of a vaccine, namely to avoid contamination and *disease dissemination*.
- *Population isolation* is a means to avoid dissemination.
- *Production costs* are related to the creation and development of any product, including medicines and vaccines.
- *Efficiency* is a property that must be considered during the test phase.

The terms used in this short analysis: purpose, properties, creation and development, etc. are foundational aspects of the structure of a concept, relatively well defined in the Generative Lexicon.

5. Knowledge-Driven Argument Mining

5.1. An introduction to the Generative Lexicon

The Generative Lexicon (GL) (Pustejovsky, 1995) emerged from Aristotle's notion of modes of explanation. The GL is an attempt to structure lexical semantics knowledge in conjunction with domain knowledge from several perspectives. It allows to explain a number of language phenomena such as various types of metonymies via a decompositional view of lexical meaning. Various forms of so-called 'generative

aspects of lexical combinations' have been characterized via the operation of type shifting, where the original type that is expected has been coerced to another type, allowing metaphors such as 'to devour books' or various forms of sense variations, which are frequent in language.

The GL develops some original forms of semantic typing, such as dotted types, that allow to account for the different facets of an entity (e.g. the physical and contents facets of a book), the development of a specific argument structure with semantic types, lexical paradigms, an event structure and the Qualia structure, which is the structure that is considered in our investigations.

Very briefly, the Qualia structure of an entity is a kind of knowledge repository from which various operations can be applied. The Qualia structure is composed of four fields called roles:
- the constitutive role describes the various parts of the entity and its physical properties, it may include subfields such as material, parts and components,
- the formal role describes what distinguishes the entity from other objects, i.e. the entity in its environment, in particular the entities which are more generic. It may also be structured into several subroles such as shape, dimensions, position, etc.
- the telic role describes the entity functions, uses, roles and purposes,
- the agentive role describes the origin of the entity, how it was created or produced.

These definitions are relatively vague and empirical. Roles are composed of predicates, which are related to the the argument structure and the event structure, which is not presented here. The predicates used in the different roles are a priori defined from a domain ontology or from a general purpose ontology.

A simple and well-known example is the case of *novel(X)*:
Novel(X):

$$\begin{bmatrix} \text{CONSTITUTIVE: } \begin{bmatrix} \text{PHYSICAL OBJECT: PAGES, COVER,} \\ \text{CONTENTS: CHAPTERS, STORY,} \\ \text{CHARACTERS, ETC.} \end{bmatrix}, \\ \text{TELIC: } \left[\text{CONTENTS: READ(Y,X), COMMENT(Y,X), ETC.}\right], \\ \text{FORMAL: } \left[\text{BOOK}\right], \\ \text{AGENTIVE : } \left[\text{WRITE(T,X), PUBLISH(P,X), SELL(P,X), ETC.}\right] \end{bmatrix}$$

In this informal Qualia structure, variables are in capital letters. X is the novel, Y, a reader, T, the author, P, the publisher and P, the retailer. In the constitutive, two facets of novel are encoded: the physical object and the contents. In the telic role, the main predicate is *read*; others such as *comment, criticize, illustrate*, develop various purposes. The physical facet, not represented here may contain predicates such as *print, bind*. The same remark holds for the agentive role, where, besides the authors that writes the novel, this novel is then published and sold by other actors.

Let us consider the **controversial issue**:
The vaccine against Ebola is necessary.
The Qualia structure of the head term of this statement, vaccine, is represented as follows:
Vaccine(X):

$$\begin{bmatrix} \text{CONSTITUTIVE: } \left[\text{ACTIVE\_PRINCIPLE, ADJUVANT}\right], \\ \text{TELIC: } \begin{bmatrix} \text{MAIN: PROTECT\_FROM(X,Y,D)} \Rightarrow \\ \quad \text{AVOID(X,DISSEMINATION(D))}, \\ \text{MEANS: INJECT(Z,X,Y)}, \\ \text{CONSEQUENCES: PROTECTION-BELT(D)}, \end{bmatrix}, \\ \text{FORMAL: } \left[\text{MEDICINE, ARTEFACT}\right], \\ \text{AGENTIVE : } \left[\text{DEVELOP(T,X), TEST(T,X), SELL(T,X)}\right] \end{bmatrix}$$

where X is the variable that represents the vaccine, Y is the person that is vaccinated, T is the biologist or company that develops the vaccine, Z is the doctor that makes the injection, and D is the disease associated with the vaccine. The agentive role develops the way the vaccine is created while the telic role develops its functions and purposes. Note the typing introduced in this role: main functions (protect, avoid dissemination) and the means: how these functions are realized (via an injection). This Qualia representation can be further organized, in particular to develop causal and temporal chains, e.g.:
$develop(E1,T,X) \wedge test(E2,T,X) \wedge sell(E3,T,X)$
$\wedge\ E1 < E2 < E3.$
The Qualia structure of Ebola (and more generally, of a virus) can be defined as follows:
Ebola:

$$\begin{bmatrix} \text{FORMAL: } \left[\text{VIRUS, DISEASE}\right], \\ \text{TELIC: } \begin{bmatrix} \text{INFECT(E1,EBOLA, P)} \Rightarrow \text{GET\_SICK(E2,P)} \Rightarrow \\ \Diamond\ \text{DIE(E3,P)} \wedge \text{E1} \leq \text{E2} \leq \text{E3}. \end{bmatrix} \end{bmatrix}$$

P represents here the patient that gets the disease. The purpose of Ebola is to infect people (P) who get sick and may die. There is no agentive role since there is no volition in the Ebola virus. Ebola is a constant in this representation.

As discussed above, the roles of a Qualia contain predicative expressions. A limitation is that the GL remains a relatively theoretical notion. Relatively few resources have been produced to validate the approach, except for the EEC SIMPLE project, carried out about two decades ago.

With respect to other well-known resources, the constitutive role is close to the part-of relation and the formal is close the the isa relation frequently found in ontologies and in WordNet. The constitutive role has a rich informational structure since the different types of constituents can be specified in dedicated sub-roles. The argument structure of the GL and its semantic typing is different from FrameNet which basically develops semantic roles, which are not present in the GL. Finally, VerbNet basically describes the structure of verbs, from WordNet and semantic classifications. VerbNet also provides a conceptual representation of verbs based on a small set of conceptual primitives. The GL does not offer this level of detail, and it is, in fact, not very efficient to describe verbs. The Generative Lexicon is particularly appropriate for argument mining because of the development it offers of the telic and the agentive roles. These two roles structure most of the knowledge that is required for argument mining.

5.2. A Network of Qualias

The root of the knowledge structure are the concepts that appear in the controversial issue, namely 'vaccine' and 'Ebola' and their Qualias. Then, a network of Qualias is derived from the concepts in the root , and further on. This process stops after a few stages (three or four), because the concepts at stake to mine arguments must remain functionally or causally close to the root concepts. Qualias are related via arcs where a concept is developed into its own Qualia.

For example, in the case of 'vaccine', from 'adjuvant' in its constitutive role, the following Qualia is included into the network:

Adjuvant(Y,X1):

$$\begin{bmatrix} \text{FORMAL} : \left[\text{VACCINE, MEDICINE, CHEMICALS}\right], \\ \text{TELIC:} \left[\text{DILUTE(Y,X1), ALLOW(INJECT(X1,P))}\right] \end{bmatrix}$$

where Y is the adjuvant of X1, which is the active principle of the vaccine X. The role of an adjuvant is to dilute X1, and to allow to inject it to patients P.

From the formal role of 'vaccine', the Qualia of the concept 'medicine' is included into the network:

Medicine(X):

$$\begin{bmatrix} \text{CONSTITUTIVE:} \left[\text{ACTIVE PRINCIPLE, ADDITIONS}\right] \\ \text{TELIC:} \begin{bmatrix} \text{MAIN: CURE\_FROM(X,Y,D),} \\ \text{MEANS: EAT(Z,X,Y)} \vee \text{DRINK(Z,X,Y)} \\ \vee \text{INJECT(Z,X,Y) , ETC.,} \\ \text{CONSEQUENCES: PROTECTION-FROM(D),} \\ \text{REDUCE(RISKS\_FOR(PEOPLE,X))} \end{bmatrix} \\ \text{FORMAL:} \left[\text{ARTEFACT}\right] \\ \text{AGENTIVE:} \left[\text{DEVELOP(T,X), TEST(T,X), SELL(T,X,FARE)}\right] \end{bmatrix}$$

Medecine is not exactly a super-type for 'vaccine', it is more shallow a notion. Therefore, a property inheritance is not systematic as it is in an 'isa' relations.

From the telic and agentive roles, a number of Qualias are introduced into the network. First, entities such as D (disease) or Y (patient) introduce their Qualias in the network. Next, predicates such as develop, test, protect, etc. introduce their own Qualia. Qualias which deal with abstract notions are more difficult to develop and make argument mining less accurate. For example, test(X,Y,T) applied to medicines:

test(X,Y, T): test X about Y by T on A:

$$\begin{bmatrix} \text{CONSTITUTIVE:} \left[\text{PARTS OF A TEST: DATA, PROTOCOL}\right] \\ \text{TELIC:} \begin{bmatrix} \text{MAIN: EVALUATE(T, PROTECTION(X,Y, A)),} \\ \text{EVALUATE(T, SIDE-EFFECTS(X,Y, A))} \\ \text{MEANS:} \end{bmatrix} \\ \text{FORMAL :} \left[\text{SCIENTIFIC ACT}\right] \\ \text{AGENTIVE :} \left[\text{ELABORATE(T,X)}\right] \end{bmatrix}$$

5.3. Pairing Qualia concepts with language patterns

The objective is to associate with every concept in the Qualia a number of language structures that allow the recognition of these concepts in texts. These language structures cover base forms (e.g. predicate argument structures) and various transformations such as alternations. Finally, they are embedded into argument expression structures, such as those presented in 4.2.

The initial goal is therefore, given a Qualia to identify language forms which directly refer to the concepts it is composed of. If we consider the Qualia of vaccine, we have, for example for the telic role, which is the most productive in terms of argument mining:

protect_from(X,Y,D) : associated language pattern:
`[X:vaccine/medicine PRED:protect Y:human FROM D:disease]`

where vaccine, medicine, human and disease are lexical semantic types. 'Protect' is the verb type, which can be lexically realized by various terms which are more or less prototypical, such as: *avoid, protect, immunize, keep away*, and their nominal counterparts: *protection*. The primitive FROM can be lexicalized as any preposition that conveys this notion. This type of pattern is close to those found in VerbNet and, to a lesser extend, in FrameNet. Their usages is however restricted to the domain at stake, therefore, the lexical semantic types may be more restricted.

avoid(dissemination(D)) : associated language pattern:
`[X:vaccine/medicine Pred :avoid DISSEMINATION of D :disease]`

The concept DISSEMINATION can be realized in any lexical form that captures this notion, e.g.: *dissemination, diffusion, dispersal, spreading*.

The same approach is used for any predicative term in the telic or agentive roles. The use of higher-order predicates (such as 'avoid') induces a pattern that includes such verbal constructions. Nominal concepts found in the constitutive and formal roles are associated with their lexical realization(s) andq with evaluative expressions: *adjuvant is toxic*.

5.4. From language patterns to utterances

In argument expression, the patterns presented in the previous section are realized as language utterances with some specific syntactic constructions proper to argument expression (section 4.2). A first set of realizations deals with evaluative expressions. The following constructions are frequently observed:

- negation of the VP mainly with not and do not.
- adverbs of frequency and compounds:*never, almost never, seldom, rarely, not frequently, very frequently*,
- modals expressing doubts or uncertainty: *seem, could, should*,
- evaluations: *100%, totally, systematically*, or via adjectives that evaluate the concept: *toxic, useless*, etc.

These constructs allow to evaluate e.g. how purposes and goals are reached: *the vaccine is not fully tested; it seems to protect people from Ebola*.

The other types of expressions described in 4.2 are derived in the same way. From the different terms which compose these expressions, dedicated semantic composition rules

derive the orientation of the argument w.r.t. the issue. From the concepts from the Qualias which are used, the facet that is supported or attacked is induced, for example the 'test', 'protection' or 'dissemination' facets. A facet is defined from one or more combinations of concepts in the network of Qualias.

5.5. A few illustrative case-studies

Let us now illustrate our proposal via a few use-cases given the controversial issue: *The vaccine against Ebola is necessary*. Let us assume that an utterance such as A1 is found in a text. the problem is to identify if it is related to the issue, and, if so, how and what is its polarity.

Argument A1: *The adjuvant is toxic for humans*
This statement a priori negatively evaluates the adjuvant (assuming it is related to the Ebola vaccine). The constitutive role of *vaccine(X)* says that the adjuvant is part of the vaccine. The Qualia of adjuvant is given in 5.2 indicates that the adjuvant is mixed via dilution with the active principle of the vaccine:
(1) The purpose of dilute(Y,X1) (given in its telic role) is that Y and X1 are mixed together and form a single entity: the vaccine X.
Then the following reasoning schema is developed:
(1) *upwards inheritance of a property in a part-of relation*: if a (major) constitutive part K1 of an object K has a property P (i.e. toxic), then (probably) the entire object K has P (is toxic for humans):
$has\_property(K1,P) \wedge part\_of(K1,K) \Rightarrow has\_property(K,P)$.
(2) since Y and X1 are parts of X, and Y is injected with X1 (from the telic of adjuvant), then since Y is toxic for humans, it follows that X is also toxic for humans. Therefore, argument A1 has a negative orientation, due to the negative polarity of *toxic* (lexical feature of the adjective), therefore A1 **attacks the controversial issue**.
This statement may also be interpreted as a **contrast to the controversial issue**: 'the vaccine is necessary BUT it is toxic'. According to the semantics of a contrast (e.g. (Winterstein 2012)), the second part of the contrast, Q, in: 'P but Q', wins without being in full contradiction with the controversial issue P.

Argument A2: *The vaccine does not always protect people: 3 vaccinated people died in Monrovia*
This statement is composed of two parts: an evaluation and then a justification. This latter part is identified as justifying the main clause by our discourse analysis module, implemented in TextCoop. Let us focus on the main clause. (1) Argument A2 means that among the patients Y that got vaccinated, a few of them got sick and died:
$\exists$ *Y, patient(Y), (inject(E1,X,vaccine(ebola),Y)* $\wedge$ $get\_sick(E2,Y) \wedge die(E3,Y))$
(2) Then it follows from the telic of vaccine(X) that:
$\neg \Box(protect\_from(X,Y,ebola))$.
(3) Argument A2 attacks the controversial issue, which says that vaccines protect the population (with no exception). However, since the number of deaths is very limited, this statement may be interpreted either as a weak attack or as a **concession**:
Vaccine protects the population HOWEVER there are a few cases where it does not work. Informally, a concession in argumentation basically supports the controversial issue, but adds some restrictions that weaken the strength of the support.

Argument A3: *Seven persons died during the Ebola vaccine tests*
This statement reports deaths that occurred during tests. 'Die' has obviously a negative polarity. If we consider again the GL structure of vaccine(X), the 'test' activity is related to the agentive role. An axiomatization of the GL structure says:
By definition, the agentive role is pre-telic: the events it describes occur before the functions or events given in the telic role. There are a priori no relations between these two sets of events. In more formal terms, where P and Q are predicates, and E event variables:
$\forall$ *P(E)* $\in$ *agentive-role,* $\forall$ *Q(E1)* $\in$ *telic-role,*
$E < E1 \wedge \neg(P \Rightarrow Q)$.
From an argumentation point of view, A3 is **irrelevant or neutral w.r.t. the controversial issue** since tests are independent from the vaccination itself.
However, due to its very negative orientation we can say that A3 weakly attacks the issue: the vaccine must be developed, BUT tests are dangerous. It is a form of concession.
These three case studies show the type of reasoning schemes that need to be developed to identify arguments, their polarity and the facet(s) involved in the controversial issue. These need to be further elaborated and categorized to form a set of **argument mining reasoning schemes**.

5.6. Summing up

The analyses we carried out show that the boundaries between attacks, neutral, concession, contrast and support are not very clearcut, and that there is a kind of continuum between them. They also show that attacks and supports may only concern some facets of the controversial issue.
The other main interest of this analysis is that, given a set of independent statements, coming from different origins, it is possible to precisely relate them (or not) to the main issue and to identify, for each of them, if they are arguments, how they are related, their argumentative orientation and strength. This is realized by means of three main knowledge and reasoning sources:

- lexical data: via semantic features for lexical items, in particular polarity (for verbs and adjectives), intensity and modality (for adverbs and adjectives), scales for antonyms, etc.,
- domain knowledge: encoded via the Generative Lexicon Qualia structure, including event structures, causal chains and role sub-typing, in conjunction with lexical data.
- reasoning: several types of inferences have been identified:
    1. inferences related to the semantics of the Qualia roles in the GL structure,

2. inferences related to lexical semantics structures (e.g. feature inheritance, blocking),
3. inferences related to general purpose domain knowledge and to presuppositions,
4. inferences dedicated to argumentation, that allow to compute relations and their strength between the controversial issue and the argument at stake. These are specific compositionality rules.

A challenge is to identify strategies that indicate which rule or data must be triggered to analyze the relation between the potential argument at stake and the controversial issue.
Finally, another challenge is the analysis of the scalability of such an argument mining system that includes domain knowledge, in particular the development of Qualia structures. So far, there is no resource available. It seems that for a given controversial issue, or for a domain, such as those advocated in section 3.1, the number of Qualias to be developed should be lower than 50. However, while this number of Qualias allows a manual development, the introduction of automatic acquisition techniques would permit to have richer Qualias. For example, for the telic facet, purposes could be searched via language patterns (which can be encoded in TextCoop). This is an open research topic that deserves attention since Qualias seem an appropriate formalism for dealing with knowledge and linguistic data in argument mining.

6. Perspectives

This paper shows how knowledge can be introduced and paired with language processing to mine arguments. Knowledge is a major bottleneck to argument mining, given a controversial issue and a set of texts in which arguments can be found. The goal is to identify arguments, their polarity or orientation, which facet of the issue is attacked or supported and how. Our approach to argument mining is thus **knowledge driven**.
In this paper, to motivate this approach, we first developed a corpus analysis to characterize these challenges, outlining the types of knowledge required to extract and characterize arguments. We then briefly shown how the Qualia structure can be enhanced for the purpose of argument mining. Finally we developed via examples how language patterns are associated with Qualia to extract arguments.
This paper is essentially a linguistic and knowledge modeling contribution. Such a topic requires more corpus analysis, the elaboration resource development methods and techniques, and a categorization of the reasoning schemas which are involved before developing a large-scale argument mining system.

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