Argumentation Mining: The Detection, Classification and Structuring of Arguments in Text

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ABSTRACT

Argumentation is the process by which arguments are constructed and handled. Argumentation constitutes a major component of human intelligence. The ability to engage in argumentation is essential for humans to understand new problems, to perform scientific reasoning, to express, to clarify and to defend their opinions in their daily lives. Argumentation mining aims to detect the arguments presented in a text document, the relations between them and the internal structure of each individual argument. In this paper we analyse the main research questions when dealing with argumentation mining and the different methods we have studied and developed in order to successfully confront the challenges of argumentation mining in legal texts.

1. INTRODUCTION

Argumentation is the process whereby arguments are constructed, exchanged and evaluated in light of their interactions with other arguments. An argument is a set of premises, pieces of evidence (e.g. facts), offered in support of a claim. The claim is a proposition, an idea which is either true or false, put forward by somebody as true. The claim of an argument is normally called its conclusion. Argumentation may also involve chains of reasoning, where claims are used as premises for deriving further claims. The right side of Table 1 shows some argumentation examples.

Argumentation plays an important role in many areas. Many professionals, e.g. scientists, lawyers, journalists or managers, implicitly or explicitly handle arguments systematically. They routinely undertake argumentation as an integral part of their work, where they identify pros and cons to analyse situations prior to presenting some information to an audience and prior to making some decision. Furthermore, the study of argumentation is crucial in many artificial intelligence and natural language research problems. For example, reasoning agents need to communicate with each other and apply argumentation-based reasoning mechanisms to resolve the conflicts arising from their different views of goals, beliefs, and actions. Therefore, it is a crucial point to understand the characteristics and models of argumentation. Another example are question answering systems, which deal with finding the correct response to questions like *"Why was this decision taken?"* and therefore integrate the analysis of argumentation as a crucial part of identifying the answer to the questions as well as the pros and cons that make up the answer.

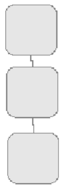
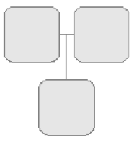
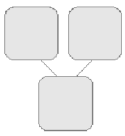
Argumentation mining is a new research area that moves between natural language processing, argumentation theory and information retrieval. The aim of argumentation mining is to automatically detect the argumentation of a document and its structure. This implies the detection of all the arguments involved in the argumentation process, their individual or local structure, i.e. rhetorical or argumentative relationships between their propositions, and the interactions between them, i.e. the global argumentation structure.

To achieve the aim of argumentation mining an adequate linguistic, formal, and computational study of argumentation is required. However, even if the study of argumentation in philosophy or law has a long tradition and many theories exist, there are questions that need to be answered when dealing with argumentation mining:

- What is the "correct" abstract structure of argumentation? Should we represent argumentation as a tree-structure or is it better to use a graph-structure? What are the constraints that characterize this structure?
- What are the elementary units of argumentation? And of an individual argument?
- What are the relations that hold between two arguments and/or argumentation units? Are they grounded into the events and the world that the text describes, or into general principles of rethoric and linguistics?
- Can the units of argumentation and/or arguments be determined automatically?
- Can argumentation structures be determined automatically? If so, how?

Evidence for the answers to these questions can come from different disciplines including philosophy, law, linguistics, computer science and others. Adequate and supported answers to them or even a summary of such answers is a challenging task. Our research is especially concerned with the last two questions, providing answers based on empirical experiments and their evaluation. For answers to the first three questions, we have studied literature on argumentation

Table 1: Examples of argumentation and their structure

Subordinatively Compound Argumentation 	*She won't worry about the exam. She's bound to pass. She's never failed.*
Coordinatively Compound Argumentation 	*This book has literary qualities: the plot is original, the story is well-told, the dialogues are incredibly natural, and the style is superb.*
Multiple Argumentation 	*Postal deliveries in Holland are not perfect. You cannot be sure that a letter will be delivered the next day, that will be delivered to the right address, or that it will be delivered early in the morning.*

and discourse theory that helped us in designing our argumentation mining tools. In this paper we present our work on argumentation mining, moving from existing research on argumentation theory and knowledge on discourse analysis and information retrieval to the evaluation of our methods.

This paper is structured as follows. In the next section, we show different related research that has motivated the study of argumentation mining. In section three, we examine related theories of argumentation and the linguistic properties of naturally occurring argumentation. Section four presents how the knowledge of argumentation theory and discourse analysis developed in section three is used in order to detect and classify argumentation and to produce argumentative parsing algorithms that derive the argumentation structure of free text. The last section summarizes the most important points of the paper.

2. RELATED RESEARCH

Research in argumentation mining is still very limited. One of the first studies was Argumentative Zoning (AZ) [23, 22]. The authors rely on well-known statistical classifiers and very simple features to identify and classify sections on scientific documents. The features include location of a sentence within a document and within subsections and paragraphs; sentence length; whether the sentence contains a word from the title; whether the sentence contains significant terms spotted by the *tfidf* (term frequency x inverse document frequency) metric; whether the sentence contains a citation; linguistic features of the first finite verb; cue phrases; and the presence of certain named entity types, to divide scientific documents in different zones, e.g. background, aims or contrastive statements.

Argumentative Zoning was applied later on legal documents by Ben Hachey and Claire Grover [9]. The authors train a classifier on 141 House of Lords judgments and test it on 47 judgments, where a judgment contains 105 sentences on average. Different classification algorithms are used: decision tree learning algorithms, naïve Bayes classifier, support vector machines and maximum entropy modeling. Among the best results, the maximum entropy classifier shows a precision of 51% and a recall of 17%. Furthermore, first attempts to detect arguments in mathematical discourse are described by [10], while in [8] advices and warnings are automatically identified and added to a know-how repository, which can be used in a question-answering system.

3. ARGUMENTATION

Even if there is few specific research on argumentation mining, it is possible to rely on more general studies on argumentation to discern answers to the challenges of argumentation mining. One of the goals of this paper is to justify our view on argumentation, which is simple and general enough to be applicable on argumentation mining of free texts.

There are many formalisms for the description of argumentation, for example, [3] presents an argumentation formalism for reasoning agents. Nevertheless, to the best of our knowledge, none of the already existing formalisms captures all and each of the needs of argumentation mining, i.e. the need of a clear description of the minimal units of argumentation and arguments as they are found in free text, a clear description of all the possible relations between and inside these arguments, and a simple structure able to capture all possible argumentation structures found in free text. It is important to notice that our aim is not to create a formalism, but to merge already well-known theories of argumentation and discourse to meet all the needs of argumentation mining.

3.1 Background

Before presenting our view on argumentation we carefully examine some known theories of what we consider the necessary background of any argumentation research in free text, i.e. discourse theory and argumentation theory. We try to present a general overview of the state-of-the-art in those fields, paying special attention to the approaches that are, in our opinion, most valuable for argumentation mining.

3.1.1 Argumentation theory

Argumentation theory is an interdisciplinary field which attracts attention from philosophers, logicians, linguists, legal scholars, speech communication theorists, etc. The theory is grounded in conversational, interpersonal communication, but also applies to group communication and written communication. From our point of view there are three main argumentation theories that highly influence the development of argumentation mining.

First there is the research presented in [24], which focuses on the importance of a layout for an argument. This work can be seen as the precursor of any argumentation structure study. It shows that in order to analyse an argument, it is necessary to identify the key components of the information in terms of their roles played within the argument. It describes these roles as: facts, warrant, backing, rebuttal and qualified claim. However, these roles are difficult to apply in free text argumentation where chains of reasoning are complex and common.

Second, the research in [25] describes argumentation as a phenomenon of verbal communication which should be studied as a specific mode of discourse, characterized by the use of language for resolving a difference in opinion. According to pragma-dialectical theory, argumentation is always part of an explicit or implicit dialogue in which one party attempts to convince the other party of the acceptability of his or her standpoint. Following this theory, the argumentation of a free text is seen as an implicit dialogue, where the protagonist can only anticipate the antagonist's doubts or criticism; he will only advance more argumentation if he assumes that doubts or criticism are to be expected. The protagonist's argumentation is then seen as a complex whole made up of statements put forward to deal with real or anticipated critical reactions from an antagonist. According to the theory, there exists four different ways of putting forward statements for the argumentation. First, **Simple Argumentation**, where a unique defense for a standpoint is given. Second, **Multiple Argumentation** where alternative defenses of the same standpoint are given. Third, **Compound Argumentation** where a chain of arguments that reinforce each other are presented. The arguments constituting the chain can be (a) "connected in parallel", i.e. the arguments are part of a combined attempt to defend the standpoint, named **Coordinatively Compound Argumentation**, or (b) "connected in series", i.e. the one supporting the other, named **Subordinatively Compound Argumentation**.

Finally, a quite recent theory defines argumentation schemes, which offer a means of characterising stereotypical patterns of reasoning [27, 29, 30]. The theory establishes that each argumentation scheme has a matching set of critical questions. The argumentation scheme and the matching critical questions are used to evaluate a given argument in a particular case, in relation to a context or dialogue in which the argument occurred. An argument used in a given case is evaluated by judging the weight of evidence on both sides at the given point in the case where the argument is used. If all the premises are supported by some weight of evidence, then that weight of acceptability is shifted towards the conclusion, subject to rebuttal by the asking of appropriate critical questions. Therefore, the critical questions form a vital part of the definition of a scheme, and are one of the benefits of adopting a scheme-based approach. One of the main reasons why argumentation scheme theory is relevant for the analysis of argumentation in free text is that the schemes offer one way of processing any real world argument, even the arguments that tradionally are categorized as fallacies can be detected as appropiate and acceptable arguments in the right circumstances using argumentation schemes.

3.1.2 Discourse Theory

Argumentation mining is applied on free text and it is, therefore, dependent on the discourse characteristics of free text. Researchers in linguistics have long pointed out that text is not just a simple sequence of clauses and sentences, but rather follows a highly elaborate structure. The discourse structure of free text has been studied in depth from its rhetorical, temporal, and casual relations by different authors, see for example [7, 14, 16, 20], where the elementary units of discourse have been identified and the relations between them analysed.

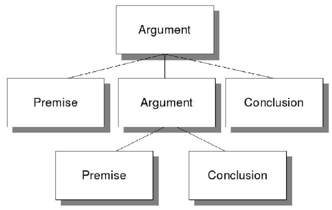


Figure 1: Argumentation tree-structure

An analysis of the statements on state-of-the-art discourse theories made with respect to the structure of text and discourse have been presented in [16, 31], finding that most discourse theories present significant commonalities. Essentially, most of these theories assume that the elementary units of complex text structures are non-overlapping spans of text; that discourse relations hold between textual units of various sizes; that some textual units play a more important role in text than others; and that the abstract structure of most texts is either a tree or a graph. Linguistic phenomena that signal rhetorical relations are lexical cues, pronouns and other forms of phoric reference, and tense and aspect [11]. The most prominent indicators are lexical cues [1], most typically expressed by conjunctions and by certain kinds of adverbial groups. The nature and number of the relations that hold between textual units have been studied in depth, some studies focus more on the writer's intentions [14] while others on the reader's processing of the text [21]. The most accepted theory is the one presented in [14], i.e. Rhetorical Structure Theory (RST). RST defines twenty-three rhetorical relations that can hold between spans of text within a discourse. Most relations hold between two text spans (often clauses or sentences), a nucleus and a satellite. The nucleus is the unit that is more central to the writer's purpose and is interpretable independently. The satellite is less central and generally is only interpretable with respect to the nucleus (e.g. an evidence relation: [$_n$ John must be here.] [$_s$ His car is parked outside.]). RST relations can be hierarchically organized into an entire discourse tree. However, the choice of which structure is best to represent a discourse is a subject of debate [31], but, given its easy formalism and automatic derivation, a tree structure is normally prefered to arbitrary graph structures.

In conclusion, discourse theory takes as axiom that any text can be partitioned into a sequence of non-overlapping, elementary textual units and that a discourse structure can be associated with the text. For example, assuming the disourse structure is a tree: (a) the elementary textual units constitute the leaves of the tree, (b) the leaves in the tree are in the same order as the elementary units in the text and (c) the tree obeys some well-formedness constraints that could be derived from the semantics and pragmatics of the elementary units and the relations that hold between these

Table 2: Examples of argumentative and non-argumentative propositions and their source text type from the Araucaria corpus

Text type	Argument	Non-argument
Discussion fora	"On this occasion, however, I shall not vote for any individual or party but will spoil my paper."	"I have been voting since 1964 and at one time worked for my chosen party."
Legal judgments	"He is aware of the risks involved, and he should bear the risks."	"Let there be any misunderstanding one point should be clarified at the outset."
Newspapers	"Labor no longer needs the Liberals in the Upper House."	"The independents were a valuable sounding board for Labor's reform plans."
Parliamentary records	"I have accordingly disallowed the notice of question of privilege."	"Copies of the comments of the Ministers have already been made available to Dr. Raghuvansh Prasad Singh."
Weekly magazines	"But for anyone who visits Rajasthan's Baran district, the apathy of the district administration and the failure of the Public Distribution System (pds) is clear to see."	"This time in Rajasthan."

Table 3: Characteristics for the ECHR and the Araucaria corpora

Characteristics	ECHR	Araucaria
Number of documents	47	641
Number of arguments	257	641
Number of words	92190	76970
Number of sentences	2571	3798

units.

3.2 Formalization for Argumentation Mining

In this section we present a formalism that is valid for argumentation mining. We do not claim that this is the only valid formalism for argumentation mining, our aim is to show the needs of any correct formalism to work with argumentation mining and to prove our formalism covers all of them.

Argumentation mining needs to process free-text and to detect natural occurring argumentation. Therefore, the description of argumentation must be able to define which are the elementary units of natural occurring agumentation, how these units interact and which structures are formed from these interactions. The following subsections discuss in detail each of these questions, merging argumentation and discourse knowledge and paying special attention to common findings found in the different studies presented on the background.

3.2.1 Elementary Units of Argumentation

It is well-known that argumentation is the process whereby arguments are constructed, exchanged and evaluated in light of their interactions with other arguments, then it is not surprising that all argumentation experts agree that the elementary units of argumentation are *arguments*.

However, the definition of an argument is more controversial. The background presented in the previous section already shows different definitions of an argument. Only one thing seems common in all of these definitions: an argument is always formed by premises and a conclusion.

In free text these premises and conclusion can be implicit (i.e. enthymemes). Therefore, some studies have mentioned that an argument can be presented as a single proposition in its minimal representation. However, even for a human at least two argumentative propositions are needed to have an appropriate certainty when distinguishing arguments from statements. Isolated argumentative propositions are hard to distinguish from simple statements. For example, the isolated sentence: "Councilwoman Radcliffe voted in favour of the tax increase." does not look like an argumentative sentence. However, when it is placed on the right context: "Councilwoman Radcliffe voted in favour of the tax increase. No one who voted in favour of the tax increase is a desirable candidate. Therefore, Councilwoman Radcliffe is not a desirable candidate.", it is completely clear that this proposition is part of an argument. Our formalism defines that the elementary units of argumentation are *arguments*, where an argument is *a set of at least two propositions.* To complete this definition is necessary to define the meaning of proposition.

In linguistics, a proposition is conveyed by a declarative sentence used to make a statement or assertion. But does argumentation mining work in a sentence level or does it need a deeper analysis on smaller text spans? Here our formalism is not constraining, and leaves this to a free-choice depending on the type of text at hand. Dialogues or unformal text will contain shorter sentences where conclusion and premise can be together in a single sentence, being each a subclause of the sentence. However, more formal texts, such as legal documents, present longer sentences with many subordinate sentences. Therefore, these texts normally present premise and conclusion in subordinate sentences or independent sentences instead of subclauses.

3.2.2 Internal Structure of Elementary Units

Given that the definition of an argument proposed in the previous section is not complete, we need to define the nature and relations that hold between the propositions of an argument. Essentially, most of the argumentation theories assume that the propositions can be classified as premises and conclusions. However, as seen in the background section, more complex classifications, such as the one of Toulmin, have been presented over the years. Our formalism is based on [28] and recognizes only premises and conclusions, assuming that each argument follows an argumentation scheme, that defines relations between propositions

{ [*SUPPORT*: The Court recalls that the rule of exhaustion of domestic remedies referred to in Article x of the Convention art. x obliges those seeking to bring their case against the State before an international judicial or arbitral organ to use first the remedies provided by the national legal system.
CONCLUSION: Consequently, States are dispensed from answering before an international body for their acts before they have had an opportunity to put matters right through their own legal systems.]

[*SUPPORT*: The Court considers that, even if it were accepted that the applicant made no complaint to the public prosecutor of ill-treatment in police custody, the injuries he had sustained must have been clearly visible during their meeting.
AGAINST: However, the prosecutor chose to make no enquiry as to the nature, extent and cause of these injuries, despite the fact that in Turkish law he was under a duty to investigate see paragraph above.
SUPPORT: It must be recalled that this omission on the part of the prosecutor took place after Mr Aksoy had been detained in police custody for at least fourteen days without access to legal or medical assistance or support.
SUPPORT: During this time he had sustained severe injuries requiring hospital treatment see paragraph above.
CONCLUSION: These circumstances alone would have given him cause to feel vulnerable, powerless and apprehensive of the representatives of the State.]

CONCLUSION: The Court therefore concludes that there existed special circumstances which absolved the applicant from his obligation to exhaust domestic remedies. }

Figure 2: An example of legal argumentation with two sub-arguments

reflecting reasoning patterns. Therefore, our definition of argument is established as: "an argument is set of propositions, being all of them premises, except maximum one, which is a conclusion. Any argument follows an argumentation scheme, where the critical questions can be implicit or explicit".

3.2.3 Relations between Elementary Units

Once it is clear which are the elementary units of argumentation, i.e. arguments, it is necessary to define the nature, number and classification of the relations that can hold between these units. Given the aim of argumentation mining to work over free text, the approach of [25], where arguments relate through coordination, subordination or form a multiple argumentation relation, seems the most appropiate to our formalism.

3.2.4 Argumentation Structure

The previous definitions of the elementary units of argumentation and the possible relations between them facilitate the choice of an argumentation structure. The use of [25] for the definition of the relations instead of theories such as [24] or [4], allows us to see argumentation as a tree-structure, instead of a more complex graph-structure. The leaves of the tree are arguments, with premises and conclusion, which converge into other arguments, i.e. being premises of higher tree-nodes, which is shown in Figure 1.

4. ARGUMENTATION MINING

The description of argumentation given in the previous section is aimed to help achieving the challenges of argumentation mining, which are: (a) identify the arguments presented in a free text, (b) identify the internal structure of each individual argument, i.e. the interactions between the different propositions forming the argument, and (c) identify the interactions between the arguments, i.e. the argumentation structure.

First, we present the definition of the corpora used for the evaluation of the challenges, then we focus on the methods we have studied to solve the problems of argumentation mining. Each problem is discussed in a subsection, which describes the scope and setting of the task, the methods studied to handle it and their evaluation.

4.1 Corpora

The correctness of all the methods proposed in the following sections has been evaluated using two corpora. On one hand we use a general corpus, known as the Araucaria corpus. This corpus comprises two distinct sets of data: a structured set in English collected and analysed according to a specific methodology as a part of a project at the University of Dundee (UK), and an unstructured multi-lingual set of user-contributed analyses. Only the structured data was used for our analysis. The data was collected from 19 newspapers (from the UK, US, India, Australia, South Africa, Germany, China, Russia and Israel, in their English editions where appropriate), 4 parliamentary records (in the UK, US and India), 5 court reports (from the UK, US and Canada), 6 magazines (UK, US and India), and 14 further online discussion boards and "cause" sources such as HUman Rights Watch (HURW) and GlobalWarming.org. The corpus is formed by an equal number of sentences that contain an argument and sentences without arguments, see Table 3. The sentences are also classified by their text type: newspapers, parliamentary records, legal judgments, weekly magazines, discussion fora, "cause" sources and speeches.

The second corpus we use in our evaluations is the ECHR corpus, a set of documents extracted from legal texts of the European Court of Human Rights (ECHR). The ECHR, over the years, has developed a standard type of reasoning and structure of argumentation. Therefore, its documents are a perfect test set for argumentation analysis. In Table 3 the main characteristics of the ECHR training and test corpora are cited. The dataset deals with different human rights (e.g. child rights, immigration or torture). Figure 2 shows an example of argumentation from a sample ECHR legal case with its corresponding annotation. A detailed study on the section structure of the ECHR documents can be found in [18]. The distribution of premises, conclusions and non-argumentative sentences in the corpus shows a clear unbalance between premises and conclusions, being the number of premises 763 while the number of conclusions is just 304 and the number of non-argumentative sentences is 1449. This is a normal characteristic of any argumentation, where con-

Table 4: Features used in the classification of detected arguments

Unigrams	Each word in the sentence.
Bigrams	Each pair of successive words.
Trigrams	Each three successive words.
Adverbs	Detected with a part-of-speech (POS) tagger (e.g. QTag [1]).
Verbs	Detected with a POS tagger. Only the main verbs (excluding "to be", "to do" and "to have") are considered.
Modal auxiliary	Indicates if a modal auxiliary is present using a POS tagger.
Word couples	All possible combinations of two words in the sentence are considered.
Text statistics	Sentence length, average word length and number of punctuation marks.
Punctuation	The sequence of punctuation marks present in the sentence is used as a feature (e.g. ":."). When a punctuation mark occurs more than once in a row, it is considered the same pattern (e.g. two or more successive commas both result in ",+").
Key words	Keywords refer to 286 words or word sequences obtained from a list of terms indicative for argumentation [12]. Examples from the list are "but", "consequently", and "because of".
Parse features	In the parse tree of each sentence (e.g. Charniak [6]) we used the depth of the tree and the number of subclauses as features.

clusions tend to be justified by many premises to ensure a complete and stable justification of each standpoint [18].

There are many reasons to focus on the legal domain when studying argumentation. First, argumentation plays a central role in law practice. Second, studying argumentation in the legal domain enables to consider factors that go beyond the very abstract, proof centred arguments of, for example, mathematics, while retaining a certain formal structure, as against the rather anarchic arguments found in everyday conversation. Third, the legal domain needs commercially viable systems for argument recognition, and these systems need to be grounded in a generic framework, which is one of the aims of argumentation mining.

4.2 Argument Detection

The detection of all the arguments presented in a free text is similar to the binary classification of all the propositions of the text as argumentative or non-argumentative. If each proposition of the text can be classified as being part of the argumentation or not, then all units classified as argumentative constitute together all the arguments of the text. However, this approach presents a limitation, as the delimiters of each argument are not defined. Therefore, it is known which information forms the arguments, but not how this information is splitted into the different arguments. This is known as a segmentation problem.

First, we analyse the classification problem. Following the work of [22] and [9] we studied the use of statistical classifiers, e.g. naïve Bayes, maximum entropy model or support vector machines. Our best results were achieved using one of the following two classifiers. First, the maximum entropy model, which adheres to the maximum entropy principle [2]. This principle states that, when we make inferences based on incomplete information, we should draw them from that probability distribution that has the maximum entropy permitted by the information we have. In natural language we often deal with incomplete patterns in our training set given the variety of natural language patterns that signal similar content. Hence, this type of classifier is frequently used in information extraction from natural language texts, which motivates our choice of this classifier. Second, the naïve Bayes classifier, specifically a multinomial naïve Bayes classifier [15], which learns a model of the joint probability of an element x and its label y, p(x, y), and makes its predictions by using Bayes rule to calculate p(y|x) and then selects the most likely label y. It makes the simplifying (naïve) assumption that the individual features are conditionally independent given the class. The features are typically represented as binary values and the frequency of occurrence within a class is taken into account when training (see Table 4).

We obtained nearly 73% accuracy when detecting arguments in the Araucaria corpus [19]. The accuracy increases to 80% when the task is performed on the ECHR corpus [2].

These results prove that the classification of sentences as argumentative or non-argumentative is feasable. In a next step, we focus on how to determine the argument limits. Some first solutions to this segmentation problem are as follows. First, it is possible to use the structure of the document, i.e. the sections and subsections, to determine where an argument starts or ends. This approach assumes that an argument can not expand between sections or sub-sections. However, this has obvious limitations, as it is not hard to think of an argument divided in different sub-sections, one presenting the premises and another the conclusion. Therefore, this option is dependent on the type of text at hand. A second option aims to understand the semantics of the different arguments. For example, one could calculate the semantic distance between the different argumentative units (e.g., sentences), and group sentences in one argument if they discuss content that is semantically related. Besides computing semantic relateness this method must deal with ambiguity, coreference and pronoun resolution.

We assume that the relatedness of two sentences is a function of the relatedness of their words. There are several approaches for calculating semantic relateness of words, the most important being ontology and corpus based. In the former, the relatedness of words depends on their semantic distances in a lexioo-semantic resource such as WordNet [5]. In corpus-based semantic measurement the semanic related-

[2]The results presented on [17] were 90%, but the evaluation was done on a previous version of the ECHR corpus. The new version uses the same texts but with an improved human annotation, where a higher agreement between annotators is achieved.

Table 5: Features for the classification of argumentative propositions

Absolute Location	Position of sentence absolutely in document; 7 segments
Sentence Length	A binary feature, which indicates that the sentence is longer than a threshold number of words (currently 12 words).
Tense of Main Verb	Tense of the verb from the main clause of the sentence; having as nominal values "Present", "Past" or "NoVerb".
History	The most probable argumentative category (among the 5 categories) of previous and next sentences).
Information 1st Classifier	The sentence has been classified as argumentative or non-argumentative by a first classifier.
Rhetorical Patterns	Type of rhetorical pattern ocurring on current, previous and next sentences (e.g. "however,"); we distinguish 5 types (Support, Against, Conclusion, Other or None).
Article Reference	A binary feature indicating whether the sentence contains a reference to an article of the law, detected with a POS tagger [26].
Article	A binary feature indicating that the sentence includes the definition of an article detected again with the help of a POS tagger [26].
Argumentative Patterns	Type of argumentative pattern ocurring in sentence; we have distinguished 5 types of patterns in accordance with our 5 categories (e.g. "see, mutatis mutandis,", "having reached this conclusion", "by a majority").
Type of Subject	The agent of the sentence is the applicant, the defendant, the court or other. The type of agent is detected with the POS tagger.
Type of Main Verb	Argumentative type of the main verb of the sentence; we distinguish 4 types (premise, conclusion, final decision or none), implemented as a list of corresponding verbs, which are detected in the text also with a POS tagger [26].

ness is calculated by exploring statistical word correlations. It is assumed that similar words usually occur with the same surrounding words.

4.3 Argumentative Proposition Classification

If the detection of the argumentative propositions of a text is possible, then it seems that the classification of these propositions by their argumentative function should also be feasible. Following our formalism, we have studied the classification between premises and conclusions. Our approach is again to work with statistical classifiers.

We first classify the clauses of sentences, obtained using a parsing tool, as being argumentative or not with a maximum entropy classifier (see previous section) using the features discussed in Table 4). In a second step we use a second classifier, a support vector machine for classifying each argumentative clause found into a premise or conclusion. Here, we use more sofisticated features (see Table 5). From the new features, the first three features are selected in accordance with our previous work, as they are based on the general structure of the text and each sentence. The *History* feature models local context; it takes the category of the previous sentence as a feature, as there are often patterns of categories following each other. During the testing, the category of the previous sentence is only probabilistically known, which is why beam search is performed. We define the following novel features. For example, the *Rhetorical Patterns* feature models discoursive relations, but it distinguishes the presence of discoursive cues highly related to argumentation, expressed in two types (*premise* or *conclusion*), and the discoursive cues (*other*) which are not related to the presence of a premise or conclusion. The *Article* and *Article reference* tend to mark the role of premises, while *Type of Main Verb* signals that verbs as *conclude* or *decide* have a higher chance of being the main verb of a conclusion than verbs like *recall* or *note*. These verbs are common in argumentative speech in the legal domain, but not restricted to it, and furthermore, they can be easily extended based on linguistic knowledge, e.g. using the verb classes defined in [13].

Table 6 and Table 7 show the best results for clause classification into premise or conclusion attaining a 68.12 % and 74.07 % F_1 measure respectively. The use of a more general list of verbs or even a detection of main verbs just with a POS tagger is still ongoing research, but it is expected that this generalisation will decrease the performance, however we do not expect a high decrease, at least not when working with legal texts, where the language cues are more explicit and more restrictive than in open speech. Figure 3 shows an example of the classifier output.

Table 6: Results from the classification of *Conclusions* in the ECHR

Classifier Combination	Precision	Recall	F-Measure
Max.Ent. and Support Vector Machine	77.49	60.88	74.07
Context-free Grammar	61.00	75.00	67.27

Table 7: Results from the classification of *Premises* in the ECHR

Classifier Combination	Precision	Recall	F-Measure
Maxt.Ent. and Support Vector Machine	70.19	66.16	68.12
Context-free Grammar	59.00	71.00	64.03

1. The applicant, who was detained between 26 January and 30 March 1990, complains that this deprivation of liberty was contrary to Article 5 paras. 1, 3 and 4 (Art. 5-1, 5-3, 5-4) of the Convention. | -1
Article 5 para. 1 (Art. 5-1) of the Convention guarantees the right to liberty and security of person, subject to certain exceptions, such as the lawful detention of a person after conviction by a competent court, within the meaning of sub-paragraph (a) of the provision. | 0
Article 5 paras. 3 and 4 (Art. 5-3, 5-4) provide certain guarantees of judicial control of provisional release or detention on remand pending trial. | 0
The Commission notes that the applicant was detained after having been sentenced by the first instance court to 18 months' imprisonment. | 0
He was released after the Court of Appeal reviewed this sentence, reducing it to 15 months' imprisonment, convertible to a fine. | 0
The Commission finds that the applicant was deprived of his liberty "after conviction by a competent court" within the meaning of Article 5 para. 1 (a) (Art. 5-1-a) of the Convention. | 1
The Commission also finds no evidence in the case to suggest an infringement of paragraphs 3 and 4 of Article 5 (Art. 5-3, 5-4): | 1
The applicant was not detained on remand prior to his trial and the judicial control of the lawfulness of his subsequent detention after conviction was provided by the first instance court (cf. Eur. Court H.R., De Wilde, Ooms and Versyp judgment of 18 June 1971, Series A no. 12, p. 40, para. 76). | 0
It follows that this part of the application is manifestly ill-founded and must be rejected in accordance with Article 27 para. 2 (Art. 27-2) of the Convention. | 1

Figure 3: ECHR legal case fragment with naive bayes classification (0:Premise, 1:Conclusion, -1:Non-argumentative)

Table 8: Terminal and non-terminal symbols from the context-free grammar used in the argumentation structure detection

T	General argumentative structure of legal case.
A	Argumentative structure that leads to a final decision of the factfinder $A = \{a_1, ..., a_n\}$, each a_i is an argument from the argumentative structure.
D	The final decision of the factfinder $D = \{d_1, ..., d_n\}$, each d_i is a sentence of the final decision.
P	One or more premises $P = \{p_1, ..., p_n\}$, each p_i is a sentence classified as premise.
C	Sentence with a conclusive meaning.
n	Sentence, clause or word that indicates one or more premises will follow.
s	Sentence, clause or word neither classified as a conclusion nor as a premise ($s! = \{C\|P\}$).
r_c	Conclusive rhetorical marker (e.g. therefore, thus, ...).
r_s	Support rhetorical marker (e.g. moreover, furthermore, also, ...).
r_a	Contrast rhetorical marker (e.g. however, although, ...).
r_{art}	Article reference (e.g. terms of article, art. para. ...).
v_p	Verb related to a premise (e.g. note, recall, state,...).
v_c	Verb related to a conclusion (e.g. reject, dismiss, declare, ...).
f	The entity providing the argumentation (e.g. court, jury, commission, ...).

4.4 Detection of the Argumentation Structure

The detection and classification of argumentative propositions by statistical classifiers has been analysed in the previous section, however this approach does not allow the detection of relations between full arguments. To determine the limits of an argument and the relations it holds with other surrounding arguments is a difficult task. First, there is no limit to the length an argument can take, and we lack any knowledge on what the most probable structures formed by premises and conclusions are. Secondly, even if the argument limits could be detected, how can we know which are the most probable relations between it and other arguments?

Using the work of Marcu [16] on Rhetorical Structure Theory and the research done in POS tagging, i.e. determinig the POS of every word in a sentence, as motivation we have studied the possibility of argumentative parsing. There exist different parsing approaches: rule-based (hand-crafted, transformation-based learning) or statistical (Hidden Markov Model, maximum entropy model, memory-based, decision tree, neural network, linear models), but for the time being we have focused on parsing the texts by means of manually derived rules that are grouped into a context-free grammar (CFG).

A CFG defines a formal language, i.e. the set of all sentences (strings of words) that can be derived by the grammar. Sentences in this set said to be grammatical, while sentences outside this set said to be ungrammatical. Formally a context-free grammar G is described as $G =< T, N, S, R >$ where: T is the set of terminal symbols (represented with non-capital letters), i.e. symbols that form the parts of the statements, N is the set of non-terminal symbols (represented with capital letters), i.e. symbols that generate statements by substitution of either other nonterminals or terminals or some combination of these, S is the start symbol and R are the rules/productions of the form $X \rightarrow \beta$, where X is a non-terminal symbol and β is a sequence of terminal and non-terminal symbols.

Argumentative parsing is a difficult task, therefore we focus our efforts on proving that it is a promising approach and we restrict our research to a limited complexity. Our approach is for the moment only related to the legal domain, which makes the task easier, at least when drafting the rules manually. Using information extracted from 10 ECHR documents we define the context-free grammar shown in Figure 4 using the terminal and non-terminal symbols defined in Table 8. The grammar is explained in detail in [18]. We focus on common expressions encountered in the legal documents, such as *"For these reasons"*, *"in the light of all the material"* or *"see mutatis mutandis"*, and rhetorical markers, such as *"However"* or *"Furthermore"*. These common expressions allow drawing up rules such as: $\forall_x[isPremise(x_i) \wedge startsHowever(x_{i+1}) \rightarrow isPremise(x_{i+1})]$. We implement it using java and JSCC[3].

$$T \Rightarrow A^{+}D$$

$$A \Rightarrow \{A^{+}C|A^{*}CnP^{+}|Cns|A^{*}sr_{c}C|P^{+}\}$$

$$D \Rightarrow r_{c}f\{v_{c}s|.\}^{+}$$

$$P \Rightarrow \{P_{verbP}|P_{art}|PP_{sup}|PP_{ag}|sP_{sup}|sP_{ag}\}$$

$$P_{verbP} = sv_{p}s$$

$$P_{art} = sr_{art}s$$

$$P_{sup} = \{r_{s}\}\{s|P_{verbP}|P_{art}|P_{sup}|P_{ag}\}$$

$$P_{ag} = \{r_{a}\}\{s|P_{verbP}|P_{art}|P_{sup}|P_{ag}\}$$

$$C = \{r_{c}|r_{s}\}\{s|C|r_{c}P_{verbP}\}$$

$$C = s^{*}v_{c}s$$

Figure 4: Context-free grammar used for argumentation structure detection and proposition classification

Using the context-free grammar for parsing the texts we obtain around 60% accuracy in detecting the argumentation structures, while maintaining around 70% F_1-measure for recognizing premises and conclusions. Figure 4.4 is a small example of the argumentative structure of a document in the ECHR corpus.

5. CONCLUSIONS

This paper reports on research on argumentation mining. We have first presented the motivation for our work, moving from argumentation theory to discourse theory and linguistics. Then, we have defined and motivated the formalism of argumentation used in our research, which includes knowledge on rhetorical structure, argumentation and natural language processing. Finally, we have discussed different problems encountered when dealing with argumentation mining. For each problem we have analysed and evaluated possible solutions in both legal and non-legal domain texts, encouraging further research in some of the approaches, such as argumentative grammars, where grammars able to cope with more different and complex argumentation structures could be defined.

[3]http://jscc.jmksf.com/

```
T
|--D
|  |--x: For these reasons, the Commission by a majority
|        declares the application admissible, without
|        prejudging the merits.
|--A
|  |--c: It follows that the application cannot be
|  |     dismissed as manifestly ill-founded.
|  |--A
|     |--P
|        |--p: It considers that the applicant 's
|        |     complaints raise serious issues of fact
|        |     and law under the convention, the
|        |     determination of which should depend on
|        |     an examination of the merits.
|        |--p: The Commission has taken cognizance of
|              the submissions of the parties.
|--A
   |--c: In these circumstances, the Commission finds
   |     that the application cannot be declared
   |     inadmissible for non-exhaustion of domestic
   |     remedies.
   |--A
      |--P
         |--p: The Commission recalls that article art. x
         |     of the convention only requires the
         |     exhaustion of such remedies which relate
         |     to the breaches of the convention alleged
         |     and at the same time can provide effective
         |     and sufficient redress.
         |--P
            |--p: The Commission notes that in the
            |     context of the section powers the
            |     secretary of state has a very wide
            |     discretion.
            |--P
               |--p: The Commission recalls that in the
               |     case of temple v. the united kingdom
               |     no. x dec. d.r. p.
               |--P
                  |--p: The Commission held that
                  |     recourse to a purely discretionary
                  |     power on the part of the secretary
                  |     of state did not constitute an
                  |     effective domestic remedy.
                  |--p: The Commission finds that the
                        suggested application for
                        discretionary relief in the instant
                        case cannot do so either.
```

Figure 5: Tree Structure of an argument

6. REFERENCES

[1] J. Allen. *Natural language understanding (2nd ed.)*. Benjamin-Cummings Publishing Co., Inc., Redwood City, CA, USA, 1995.

[2] A. L. Berger, V. J. D. Pietra, and S. A. D. Pietra. A maximum entropy approach to natural language processing. *Comput. Linguist.*, 22(1):39–71, 1996.

[3] P. Besnard and A. Hunter. *Elements of Argumentation*. The MIT Press, 2008.

[4] L. Birnbaum. Argument molecules: a functional representation of argument structures. In *Proceedings of the Third National Conference on Artificial Intelligence (AAAI-82)*, pages 63–65, Pittsburgh, PA, August 18-20 1982.

[5] E. Budanitsky and G. Hirst. Evaluating WordNet-based measures of lexical semantic relatedness. *Computational Linguistics*, 32:13–47, 2006.

[6] E. Charniak. A Maximum-Entropy-Inspired Parser. Technical Report CS-99-12, 1999.

[7] R. Cohen. Analyzing the Structure of Argumentative Discourse. *Computational Linguistics*, 13:11–24, 1987.

[8] L. Fontan and P. Saint-Dizier. Constructing a know-how repository of advices and warnings from procedural texts. In *DocEng '08: Proceeding of the*

eighth ACM symposium on Document engineering, pages 249–252, New York, NY, USA, 2008. ACM.

[9] B. Hachey and C. Grover. Automatic legal text summarisation: experiments with summary structuring. In *ICAIL '05: Proceedings of the 10th international conference on Artificial intelligence and law*, pages 75–84, New York, NY, USA, 2005. ACM.

[10] H. Horacek and M. Wolska. Interpreting semi-formal utterances in dialogs about mathematical proofs. *Data Knowl. Eng.*, 58(1):90–106, 2006.

[11] E. H. Hovy. Automated discourse generation using discourse structure relations. *Artificial Intelligence*, 63(1-2):341–385, 1993.

[12] A. Knott and R. Dale. Using linguistic phenomena to motivate a set of rhetorical relations. Technical report, Discourse Processes, 1993.

[13] B. Levin. *English Verb Classes and Alternations: A Preliminary Investigation.* Chicago: The University of Chicago, 1993.

[14] W. C. Mann and S. A. Thompson. Rhetorical structure theory: Toward a functional theory of text organization. *Text*, 8(3):243–281, 1988.

[15] C. D. Manning and H. Schütze. *Foundations of Statistical Natural Language Processing.* The MIT Press, June 1999.

[16] D. Marcu. The rhetorical parsing of unrestricted texts: a surface-based approach. *Comput. Linguist.*, 26(3):395–448, September 2000.

[17] R. Mochales and M.-F. Moens. Study on Sentence Relations in the Automatic Detection of Argumentation in Legal Cases. In *Legal Knowledge and Information Systems. Jurix 2007.* IOS Press, 2007.

[18] R. Mochales and M.-F. Moens. Study on the Structure of Argumentation in Case Law. In *Legal Knowledge and Information Systems. Jurix 2008.* IOS Press, 2008.

[19] M.-F. Moens, E. Boiy, R. Mochales, and C. Reed. Automatic detection of arguments in legal texts. In *ICAIL '07: Proceedings of the 11th International Conference on Artificial Intelligence and Law*, pages 225–230, New York, NY, USA, 2007. ACM Press.

[20] M. Moser and J. D. M. T. Toward a synthesis of two accounts of discourse structure. *Computational Linguistics*, 22:22–3, 1996.

[21] T. J. Sanders. Semantic and pragmatic sources of coherence: On the categorization of coherence relations in context. *Discourse Processes*, 24:119–147, 1997.

[22] S. Teufel. *Argumentative Zoning: Information Extraction from Scientific Text.* PhD thesis, University of Edinburgh, 1999.

[23] S. Teufel and M. Moens. Sentence Extraction as a Classification Task. In *Workshop 'Intelligent and scalable Text summarization', ACL/EACL 1997*, 1997.

[24] S. E. Toulmin. *The Uses of Argument.* Cambridge University Press, July 1958.

[25] F. H. Van Eemeren and Grootendorst. *A Systematic Theory of Argumentation. The pragma-dialectic approach.* Cambridge University Press, 2004.

[26] J. Wagner, D. Seddah, J. Foster, and J. van Genabith. C-Structures and F-Structures for the British National Corpus . In M. Butt and T. H. King, editors, *The Proceedings of the LFG '07 Conference*, pages 418–438, University of Stanford, California, USA, 2007.

[27] D. N. Walton. *Argumentation Schemes for Presumptive Reasoning.* Erlbaum, Mahwah NJ, USA, 1996.

[28] D. N. Walton. *The new dialectic, Conversational contexts of argument.* University of Toronto Press, 1998.

[29] D. N. Walton. *Legal Argumentation and Evidence.* Penn State Press, 2002.

[30] D. N. Walton, C. Reed, and F. Macagno. *Argumentation Schemes.* Cambridge University Press, 2008.

[31] F. Wolf and E. Gibson. *Coherence in Natural Language: Data Structures and Applications.* MIT Press, June 2006.