Argument Extraction Challenges in a New Web Paradigm

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Abstract

The exchange of comments, opinions and arguments in blogs, social media, commercial websites or wikis is transforming the Web into a modern agora, a virtual place where all types of debates take place. This wealth of information remains unexploited: the purely textual form of online arguments leaves limited room for automated processing and the available methodologies of computational argumentation focus on logical arguments, failing to properly model online debates. We envision a formal, machine-interpretable representation of debates that would enable the discovery, tracking, retrieval, combination, interrelation, extraction and visualization of the vast variety of viewpoints that already exist on the Web, in a way that goes beyond simple keyword-based processing. This paper describes this vision and the related challenges, focusing on challenges related to argument extraction.

1 Introduction

From the plain publishing of content[1] to the collaborative contribution of knowledge through social media[2] and the annotation of content with machine-processable semantic information,[3] the Web has been constantly reshaping. Recently though, the way people use the Web and the software that is being developed to support their experience has obtained a new and rather unanticipated characteristic. People around the world access the Web to rate a hotel or a restaurant; they share comments on the story and the writing style of a book; they use it to like or dislike a photograph or a video; they write opinions in blogs and discuss in forums; they substantiate opinions in wikis citing sources of diverse reliability. Currently, the Web asphyxiates with opinions and arguments related to just about any conceivable topic.

Unfortunately, all these colourful, diverse, contradictory, interesting or indifferent opinions get lost; *scripta manent*, yet opinions are currently not uploaded as machine-processable data, they are not interlinked, and it is extremely difficult for Web users to find opinions and arguments related to a particular subject, let alone to evaluate them, characterize them based on objective and subjective criteria or filter the ones that make a difference to any particular person. As arguments and debates have a structure (premise, conclusion, intended audience, supporting data or documents, attack, support or other inter-argument relationships, metadata describing the source, time of creation or context of an argument etc.), plain keyword search can only help the user collect the pages containing the prevailing arguments on a topic; manual effort is then required for making sense out of the multitude of contradictory and diverse results returned, for navigating in the graph of interconnected arguments and supportive data, or for analysing their credibility and believability.

To unlock its potential, researchers studying the Web are making efforts to change this scheme. There already exist suggestions for representing arguments using well-defined, structured formats, as well as applications that visualize arguments and their relations using graphs. This is a first step towards allowing arguments to be searched by machines, and also mined, evaluated and linked.

[1] http://en.wikipedia.org/wiki/Web_1.0
[2] http://en.wikipedia.org/wiki/Web_2.0
[3] http://en.wikipedia.org/wiki/Web_2.0#Web_3.0

However, existing efforts are falling short in two ways: first, despite some recent successes, there is still no mature technology allowing the reliable extraction of arguments from text for annotation and further automated processing (Peldszus and Stede, 2013); second, there is currently little understanding of the argumentation process in realistic contexts, as the related field of computational argumentation (Dung, 1995; Rahwan and Simari, 2009) focuses on logical arguments only, thereby failing to properly model debates of the sort that appears on the Web (and everyday life).

Indeed, real-world (including online) debates usually contain arguments that are not formally structured, may resort to unsound reasoning (e.g., proof-by-example), or employ non-logical argumentation methods (e.g., peer-pressure, use of emotionally loaded arguments, authoritative claims); these aspects have not been considered in mainstream computational argumentation. Out of the three argumentation methodologies defined by Aristotle, namely, *logos* (appeal to logic), *ethos* (appeal to authority/honesty) and *pathos* (appeal to emotions), only the former has been thoroughly studied in the context of computer science. The current state-of-the-art in computational argumentation is limited in capturing arguments of a non-purely-logical nature, which prevail in most serious debates, e.g., on global warming, politics, EU constitution, law, or the economic crisis.

We call this evolution of the Web *Debate Web* (D-Web). Its ultimate goal will be to offer the means for assisting humans in participating in debates and collective decision making processes with well-justified and persuasive arguments, as well as to an easier identification of biased, misleading or deceptive arguments. The aims of this paper are to describe this vision, and to identify the requirements and challenges of its realization; due to space limitations, emphasis will be placed on the challenges related to argument mining and extraction only, whereas other challenges related to D-Web will only be superficially analysed.

2 Motivating Example

The day began with a feeling of unrest for Steffi. The new article she is about to prepare obtains added gravity in the prospect of her country's elections next month. The topic is not unfamiliar to her; as a financial journalist she has written numerous articles in the past regarding the financial crisis and the impact of measures suggested by the International Monetary Fund (IMF) in other countries. Her intention this time is to question the diverse viewpoints on the IMF that are put forward by the different parties and to present as objectively as possible well-justified and clearly-articulated opinions both in favour and against the controversial role of IMF.

She hits "IMF policies help countries recover from financial crises" in ArgSE, the Arguments Search Engine she mostly uses when seeking for arguments on the Web, and configures its settings in "debate mode", in order to receive both supporting and refuting arguments. She has prepared a categorization of the different target groups she is interested in to drive the mining process, and has uploaded the corresponding profiles using the "Audience Characteristics" functionality of ArgSE. For instance, she would like to know what arguments can be more meaningful for unemployed young people and middle-class workers.

ArgSE consults Steffi's profile, in order to proceed with a focused search, centred primarily around the sources of information Steffi considers trustworthy, as well as other personal preferences. Her profile data guides ArgSE to accurately decide on the level of detail to apply for the construction and presentation of arguments: her expertise in financial terms is sufficient to understand arguments on the connection between unemployment and inflation, but those regarding social aspects of unemployment require more detailed analysis in order to be comprehended. As a result, ArgSE returns a graphic showing in a visually appealing manner the different arguments, as well as their relevant properties, including the sources (provenance) of each argument, its supporting evidence, its adequacy for a particular audience and the relationships among the arguments (attack, support etc).

Using all the available information, Steffi navigates more deeply in the graph, she filters, questions, groups and organizes the available arguments, and eventually identifies and extracts the most persuasive ones. A few hours later her article is ready. Her debate-enabled editor has assisted her in annotating the different parts of her text with a formal description of the arguments they refer to (so that search engines can identify and retrieve them), and in linking them with the respective online sources and evidence they are based upon. Steffi's own conclusions, based on the

correlation of facts she personally deduced during her research are also included (and annotated) in the text. This way, her annotated article and arguments can be stored in her electronic newspaper's argument repository for others to find and reuse. As she sends the article to her editor she feels confident that her audience will have the means to form a well-informed opinion before participating in the country's decision making process.

3 The D-Web Vision

3.1 Why: The Need for D-Web

As the Web is increasingly being used for informational purposes, the public opinion is progressively being shaped by what people read online. Online versions of traditional mass media play a major role in this shift. On the other hand, due to the easiness with which content can now be uploaded, users have started to use the Web as a podium to express themselves. However, extracting meaning out of the plethora of opinions (i.e., evaluating the credibility of information related to a subject of interest, understanding why it is important, and ultimately deciding whether to adopt or reject it) becomes increasingly difficult.

Even today's Web contains the information necessary for Steffi to complete her article. However, this information, being in textual form, is not easily retrievable or processable, so it is not appropriate for implementing the features presented in our example scenario. The Semantic Web (Berners-Lee et al., 2001) and the recent linked data hype[4] promise to overcome some of the limitations of natural-language Web pages by providing appropriate methodologies for posting interlinked semantical information (data) on the Web in machine-processable formats. However, their focus is on the representation of data, rather than arguments or opinions.

Similarly, the main tenets of computational argumentation (Besnard and Hunter, 2008; Rahwan and Simari, 2009) and the extensive research conducted in this field have direct impact on the formulation of the new Web. Yet, this field relies exclusively on the formal properties of logical arguments and factual information, making it difficult to satisfy the primal reason why opinions reach the Web in the first place, which is to be *persuasive*. This latter step is important, in order to depart from simple argument listings and logical argumentation, and support *realistic arguments* and *debates with a purpose*, i.e., debates where arguments are not-purely-logical, and have a certain aim, namely to persuade a certain audience on some topic, as happens in real-world debates.

3.2 How: The Function and Use of D-Web

In D-Web the fundamental searchable component will be the *realistic argument*. Such an argument has an internal structure, containing a logical part, but also other types of information related to its persuasiveness: the audience that it is targeted at, its provenance, the context in which it was made, the values it promotes, the popularity of the claim that it supports, evidence for its believability (e.g., links to documents, facts, or other arguments that back it up), the conditions under which it is effective or valid etc. Moreover, arguments can be interlinked in various ways, where the links may represent different types of relationships (Figure 1). Understanding the role of the different components and interconnections of realistic arguments, as well as studying the factors that affect their persuasiveness, such as emotions, trust and other logical or extra-logical considerations, will be a crucial step towards realizing the D-Web vision.

Realistic arguments will be stored in "argument bases" (the analogous to knowledge bases and ontologies) and will be used to annotate online sources, such as a collection of sentences inside a document, information retrieved from a picture etc. In the context of our example, people arguing about IMF's role in mitigating the effects of the economic crisis, will have the ability to post and interrelate arguments in a machine-interpretable way. Similarly, the IMF itself will

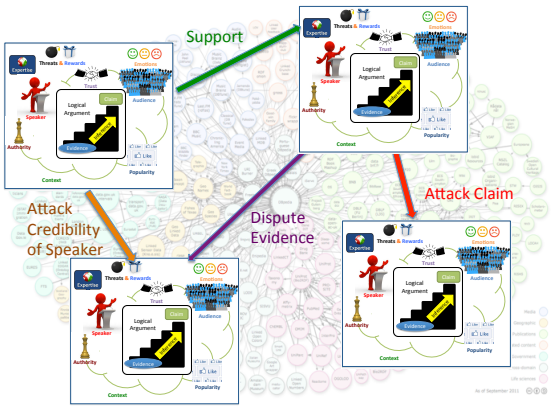

Figure 1: Arguments and data interplay in D-Web

[4] http://linkeddata.org/

be able to express its own arguments on the matter, stored in its own dedicated repository and uploaded on its website. Note that all types of digital artefacts (from financial reports to polls, simple text, images, videos, other arguments, datasets) can be used as supportive evidence for an argument. Thus, arguments and digital objects will be interrelated in two ways: arguments can be used to annotate digital objects, whereas digital objects can also be used as parts of arguments (e.g., as supportive evidence).

3.3 Who: Actors in D-Web

D-Web will provide benefits for both the content provider and the content consumer, by offering a convenient podium for expressing one's opinions and a platform for accessing opinions of others. The easy access to the enormous amounts of Web information, in tandem with the automated annotation, retrieval, exploration and analysis of realistic arguments, will allow opinions to reach a literally global audience, and, at the same time, provide a valuable tool in the hands of professionals, businesses, organizations, governments or individuals to support their decision-making processes. This will be realized via the development of new and more powerful argument-aware Web search engines and other applications that will allow users to retrieve, process, visualize, understand and query the arguments uploaded by content providers, as well as their interrelationships.

The combination of these features and tools will stimulate opinion diversity, contribute towards collective awareness and informed decision-making, promote active citizenship and e-democracy, support legal argumentation and justice attribution, allow improved fact-checking, and encourage structured and civilized argument exchange in a networked world.

3.4 What: The Goal of D-Web

The goal of D-Web is not to impose any given opinion, but to provide the medium through which a user (content consumer) can "collect" different arguments in favour and/or against a certain claim, in order to form an opinion of her own, free of prejudices and biases. The services offered by a search engine in D-Web are analogous to those of a journalist, whose role is to objectively and concisely reproduce the most prominent opinions expressed by different people or entities (e.g., political parties), in ways that help the readers better understand and evaluate them, taking into account their profiles and backgrounds. In our example, ArgSE retrieves and presents arguments only from sources that are trusted by Steffi, as well as information associated to their persuasive strength for audiences that match the profiles provided by Steffi. But it is up to Steffi to decide which of them would actually be the most influential for the readers of the newspaper she is working for.

4 Realizing the Vision

There are several research fields and state-of-the-art technologies that can provide the substrate upon which the vision of D-Web can be realized, but also important obstacles that stand in the way of its realization. Figure 2 provides an overview, showing some broad research fields and technologies that are relevant, organized along two axes.

The position of the technology along the horizontal axis represents both the current and the required maturity of each technology to solve the respective challenge. The left side of each rectangle represents the current capacity of the corresponding technology to address the related challenge, at least at a preliminary stage, whereas its right side represents additional advances that need to be achieved (and how far in the future these are estimated to occur) before actually solving the respective challenge in its entirety. On the other hand, the vertical axis represents the kind of progress required per technology (practical or theoretical) to overcome the respective challenge. The two technologies in red represent critical technologies, whose progress will guide and feed the other technologies; e.g., our understanding of realistic argumentation will define the reasoning processes that reasoning technologies should support, and such technologies should be defined in a way compatible with the state-of-the-art web technologies. Due to space limitations, we will only provide details related to the challenges associated with extraction and annotation, giving only a short summary of the remaining challenges.

4.1 Summary of Related Challenges

Understanding Realistic Argumentation. *Argumentation theory* studies how conclusions can be reached through logical reasoning in the presence of, possibly contradictory, evidence for or against a certain conclusion, whereas *argumentation systems* are logic-based computational sys-

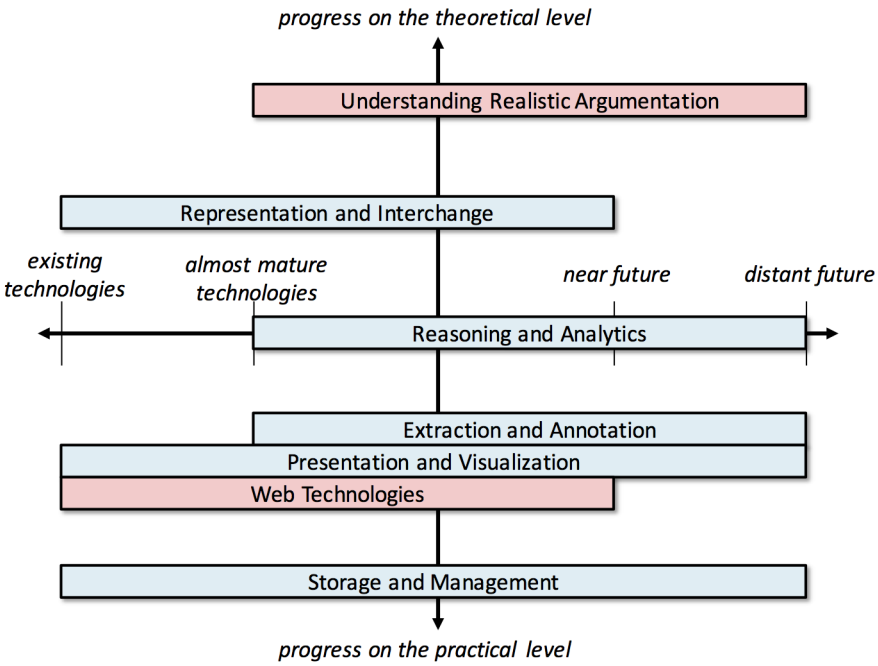

Figure 2: A 2-dimensional categorization of related technologies and challenges

tems that aim to automate this process (see (Rahwan and Simari, 2009) for a recent survey). However, D-Web is a lot more than an argumentation system deployed in a global scale. The main challenge here is the shift from *logical argumentation* (the object of study for computational argumentation) to *realistic argumentation*. Realistic argumentation does not only appeal to the logic of the audience, but also to its emotions. It is only partly based on facts and data, often employing additional techniques such as the clever use of verbal cues and the semantic structure of text/speech (politeness, aggressiveness etc), as well as different argument schemes based on factors such as appeal to authority or expert opinion, popularity of supported claims, peer-pressure, analogous arguments, proof-by-example, non-logical (e.g., statistical) correlations between different arguments, and others (Walton, 2006).

Web Technologies. The current Web is based on the simple idea of interlinking documents and making them available from everywhere. Building on the same principle, different technologies have been proposed to extend the document Web. One of the most prominent ones is the Semantic Web (Berners-Lee et al., 2001), which aims to provide machine-interpretable data on the Web (in the sense of a "global database"). Other related initiatives include the Social Web (which aims to provide tools and platforms enabling humans to communicate through blogging, tagging, Web content voting, social bookmarking and other means of social interaction) and the Pragmatic Web (Schoop et al., 2006), whose guiding principle is the observation that the content of the Web does not actually represent factual data, but the subjective opinions of the people who upload it. Closer to our vision is the Argument Web (Rahwan et al., 2007; Bex et al., 2013), which is an effort to deploy argumentation theory on the Web. However, none of these technologies fully addresses the problem, as the idea of interlinking realistic arguments has not been considered yet.

Representation and Interchange. Enabling the association and combination of arguments from different Web sites requires the development of a semantically explicit representation model (ontology) for realistic arguments, so that different independently developed applications will be able to process them in a common manner and interoperate within an integrated environment. Towards this aim, expanding existing approaches (Chesñevar et al., 2006; Rahwan et al., 2007) with an emphasis on extra-logical factors is critical.

Storage and Management. Realistic arguments will be stored in what we call "argument bases", the analogous of knowledge bases. Their struc-

ture will enable storing arguments, as well as any other information that is relevant to the proper representation of realistic arguments and debates, or their persuasiveness. Argument bases should also provide support for inference and reasoning, querying, as well as for data management (update, change monitoring, change propagation, alignment and interoperability etc). Towards this aim, the experience gained from the deployment of triple stores and other semantic data management systems in the Semantic Web will be exploited.

Reasoning and Analytics. Representing and storing arguments in an adequate format is not an objective in itself, just the means towards providing adequate services over D-Web, based on the general notions of analytics and reasoning. Through these services, the user will be able to search and navigate in arguments (possibly in an exploratory manner), pose structured queries over the pool of available arguments, or perform sophisticated (and customized) aggregation and summarization operations. In addition, sophisticated forms of reasoning may emerge, allowing the identification of implicit relationships among arguments, or the development of new forms of semantics that determine "acceptable" realistic arguments, along the tradition of abstract argumentation (Dung, 1995).

Presentation and Visualization. Given the sheer size of the Web, one expects to find a large number of arguments in favour (or against) a certain claim, so presenting everything to the user is not productive. Some kind of aggregation or summarization is necessary, along with a ranking process that will highlight the most important or relevant arguments, taking into account also issues like the diversification of opinions. It should be emphasized that ranking only aims at the practical necessity to give priority to some of the arguments; the user should be potentially capable of viewing all arguments, and no filtering or censorship should take place in the process.

4.2 Extraction and Annotation Challenges

As with all added-value technologies, the size of D-Web must reach a critical mass to make itself useful. Given the abundance of arguments already on the Web in textual form, technologies like automated mining of arguments from blogs, forums or other social media, Natural Language Processing (NLP) techniques and others, need to be employed to create structured arguments out of text.

The related research area of *argument mining* (see (Peldszus and Stede, 2013) for a survey) has already demonstrated some preliminary but promising results that could lead to reliable argument extraction and annotation in D-Web. These include annotation schemes for argument mining (Feng and Hirst, 2011; Stab and Gurevych, 2014) and methods for argument extraction from text based on NLP (Florou et al., 2013) or on combinations of techniques from Computational Linguistics and Machine Learning (Levy et al., 2014; Moens et al., 2007; Rooney et al., 2012).

The main limitation of current approaches, with respect to the needs of D-Web, is that they only capture features of logical argumentation. Furthermore, the proposed argument mining solutions are mostly based on surface linguistic features, which are not sufficient for argument extraction, because identifying the structure of an argument to some extent depends on commonsense knowledge and on the overall structure of the text document (Peldszus and Stede, 2013). Extending current argument mining approaches with the capability of identifying not only logical arguments, but also different argument schemes (e.g., argue-by-example) and additional metadata information related to the persuasiveness of an argument and the structure and context of the debate, will lead to solutions that better fit the needs of D-Web.

Moreover, multilinguality aspects should be addressed, exploiting the improving quality of automated translation tools. Also, the annotation of other types of digital objects (e.g., images, sounds) with the arguments they relate to, is also critical, as knowledge in D-Web can take various forms.

To address the shortcomings of automated annotation, at least in the short-term, human contribution could be enlisted, by adapting existing technologies such as gamification (von Ahn and Dabbish, 2008) or crowdsourcing techniques (Patkos et al., 2016a; Patkos et al., 2016b). Moreover, it is important to encourage content providers to upload arguments in a proper structured format, by providing tools that simplify the process (e.g., by allowing the semi-automatic generation of arguments and/or by aiding the content providers annotate their arguments).

5 Importance of D-Web

D-Web can be viewed as the "blog of tomorrow", where people will be able not only to express their viewpoints in a natural language, but also to annotate and connect them in a machine-interpretable manner. The expression of arguments in formal, machine-processable terms, as well as their interlinking, will create significant added-value benefits, in the same way that linked data in the current Semantic Web has led to the discovery of new, previously unseen connections, correlations and knowledge (e.g., business analytics).

The abundance of Web data, combined with machine-processable arguments, will allow the envisioned version of the Web not only to provide relevant information (as when reading a book), but also to combine available data in order to provide arguments in favour of (or against) different alternative options (as done by a knowledgeable expert). This way, people will be better informed, thus promoting collective awareness on community problems and enabling better decision-making.

At the community level, D-Web services can enable public authorities to reach a broader audience in a more personalized way, in order to foster policies of societal value (e.g., healthy lifestyle, sound environmental behaviour), to target unjustified concerns, to promote participation in community matters and democratic processes (e-democracy), or to support legal argumentation and justice attribution. At the individual level, the same services are expected to form a critical component of future autonomous entities endowed with socio-cognitive intelligence, which are used in the emerging market of smart spaces. This can find applications ranging from service robots for domestic use, to smart environments related to domestic care and work, education, healthcare, communication and entertainment.

In addition, there is a wide range of potential applications suitable for the private sector; these generally fall under marketing, e.g., persuading customers to buy products/services, convincing people to donate to a charity, etc. Similarly, D-Web can also be used as an assistive tool for individuals that practice persuasion as part of their professional life, such as lawyers, business executives etc, or for decision-makers in general, as it would allow better and more informed choices by combining information found in the Web, and also possibly in local databases, to build persuasive arguments and suggestions.

6 Conclusion

In this paper, we proposed a new Web paradigm, where the structure of realistic arguments will be explored to provide argument-aware added-value services to users. After motivating and describing our vision, we identified the main associated challenges and research/technological directions to its realization. We believe that efforts towards realizing this vision will stipulate research in a wide range of domains, scientific, academic and commercial, and can lead to the development of innovative applications that will revolutionize Web experience. Apart from its evident impact on the organization of argument and knowledge exchange on the Web, this effort opens up a way to serve a higher-level purpose: by enabling people to locate the valid rational arguments in the sea of opinions of questionable credibility, as well as those arguments that better support them, it will empower critical thinking and facilitate the active participation of humans in collective governance processes. Ultimately, we see D-Web as the platform of ideas that holds the promise for promoting the role of humans in collective decision-making and e-democracy, able to have significant impact at both the individual and the societal level.

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