Argument-based generation and explanation of recommendations

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ABSTRACT

In the recommender systems literature, it has been shown that, in addition to improving system effectiveness, explaining recommendations may increase user satisfaction, trust, persuasion and loyalty. In general, explanations focus on the filtering algorithms or the users and items involved in the generation of recommendations. However, on certain domains that are rich on user-generated textual content, it would be valuable to provide justifications of recommendations according to arguments that are explicit, underlying or related with the data used by the systems, e.g., the reasons for customers' opinions in reviews of e-commerce sites, and the requests and claims in citizens' proposals and debates of e-participation platforms. In this context, there is a need and challenging task to automatically extract and exploit the arguments given for and against evaluated items. We thus advocate to focus not only on user preferences and item features, but also on associated arguments. In other words, we propose to not only consider what is said about items, but also why it is said. Hence, arguments would not only be part of the recommendation explanations, but could also be used by the recommendation algorithms themselves. To this end, in this thesis, we propose to use argument mining techniques and tools that allow retrieving and relating argumentative information from textual content, and investigate recommendation methods that exploit that information before, during and after their filtering processes.

CCS CONCEPTS

• **Information systems** → **Recommender systems**; • **Computing methodologies** → **Discourse, dialogue and pragmatics**.

KEYWORDS

recommender systems, recommendation explanation, natural language processing, argument mining

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1 INTRODUCTION

Today, everyone is exposed to **recommendations** in streaming platforms for music (Spotify, Pandora, etc.) and video (Netflix, YouTube, etc.), e-commerce sites (Amazon, eBay, etc.), online fashion stores (Zalando, ASOS, etc.), online travel booking services (Booking.com, Yelp, etc.), and online social networks (Facebook, Twitter, LinkedIn, etc.), to name a few. Common to all these domains and applications, recommender systems analyze the activity of a typically very large set of users to provide them with (generally personalized) suggestions of options (items), based on observed evidences about their interests and preferences.

In the recommender systems field, two major traditional lines of research can be identified, namely the design of algorithms to generate personalized recommendations, and the evaluation of the recommendations provided to the users. A third line that has gained much interest in recent years concerns the **explanation of recommendations** [55]. Since the origins of the field [3, 29], explainability has been considered as a beneficial and desirable aspect for recommender systems. In particular, it has been shown that explanations, in addition to helping to improve the effectiveness of recommendations, lead to provide transparency and reliability on the systems, and thus increase user satisfaction, trust, persuasion and loyalty [60].

However, the generation and visualization of recommendation explanations are complex tasks, for which there are still no well established solutions [55]. This is largely due to the fact that model-based collaborative filtering (CF) systems, which are the ones that have achieved the best accuracy results, offer limited capabilities to explain their internal algorithms, acting as black boxes that hinder the understanding and acceptance of recommendations, and consequently compromise their effectiveness in terms of user satisfaction [46].

Advances have been made on the categorization of explanations, the characterization of methods for explanation generation and visualization, and the evaluation of explanations, generally based on user studies [43, 55]. Representative types of explanations consider: i) users and items (i.e., neighbors) that most influence CF recommendations, —e.g., showing the list of neighbors, visualizing a histogram of neighbor ratings—, ii) aspects (attributes, components) of the best/worst rated items, iii) content characteristics of the recommended items —e.g., social tag clouds–, and iv) demographic information about users with preferences on the top ranked items —e.g., percentages of users by population segments–, among others [60]. In this context, instead of providing justifications of the recommendations through explanations related to the filtering algorithms or the users and items involved in the generation of recommendations, on certain domains, it would be valuable to provide

explanations based on arguments that are explicit, underlying or related with the data used by the systems.

With the huge and ever-growing amount of user-generated content on the web, content-based recommendation and explanation methods are gaining momentum [43]. Users express and consider opinions in a wide range of tasks, applications and social media [51]. In general, opinions are provided through natural language in unstructured, free-form texts. Opinions can be detailed and focused on particular items, such as those given in reviews and blogs, or can be composed of short statements and assertions, such as those that abound in social network and microblogging services.

In the scientific literature, approaches to generating and explaining recommendations by considering such data sources have been proposed. In particular, aspect opinion-based recommender systems, which have recently received renewed interest [2, 30], aim to exploit positive and negative opinions (or sentiments) about aspects of the recommended items. The principal domains addressed with these systems have been e-commerce, entertainment (e.g., movie, music and videogame recommendations), and tourism (e.g., restaurant and hotel recommendations), where it is common for users to evaluate available items by providing textual reviews that support their ratings [13].

Despite the benefits of providing recommendations and explanations based on opinions, it would be useful to **understand and consider the reasons for given opinions** [47, 48]. Hence, there is a need and challenging task to automatically identify and exploit the arguments given for and against the evaluated items. For such purpose, we advocate to focus not only on user preferences and item features, but also on the associated arguments. In other words, we propose to not only consider what is said about items, but also why it is said. In this sense, it would be also desirable to represent arguments in structured, computer-processable forms, which allow to interconnect arguments, e.g., through relationships in favor or against, and even to contrast them with objective (perhaps external) facts. This would be beneficial for both traditional recommendation domains, such as e-commerce, leisure and tourism –where specific websites are plenty of user reviews–, and less common domains that are rich in argumentative information; in particular, web forums and electronic platforms for discussion and debate, and software tools that handle argumentative content, e.g., legal corpora, educational resources, collections of citizens' proposals, and transcripts of politicians' speeches. In all these domains, argumentative information would not only be part of the recommendation explanations, but could also be exploited by the recommendation algorithms themselves.

Taking all the above issues into account, **argument-based recommender systems** operate with arguments –justifications of opinions, and evidences of objective facts— before, during and after their filtering processes. Surveying the scientific literature on argument-based recommender systems (see Section 2.2), we find out that so far, the developed recommendation methods are, in general, ad hoc heuristic solutions to specific problems, which have been preliminarily evaluated with relatively small (manually) annotated datasets and without following rigorous methodologies.

By contrast, in the argument mining field [40], there are prior work and active efforts on the **automatic extraction of argumentative information from textual content**, to generate structured, computer-processable argument data [9, 31, 35, 36, 41]. Hence, a number of domain applications have been identified [35]: e-commerce (e.g., analysis of reviews for a better understanding of user opinions about products and services), social media (e.g., analysis of discussion and controversy in user-generated content from online social networks and debate web portals); health (e.g., analysis of the veracity of opinions on health issues on the internet), law (e.g., review of trial records and court decisions), politics (e.g., analysis of parliamentary speeches), science (identification of the motives and purposes of citations in scientific articles), and journalism (e.g., review of the state of the art for a topic, and analysis of debates in the media).

For these and other applications, personalized search and recommendation of arguments are key functionalities, which can be further investigated. The proposed thesis aims to bring together the research fields of argument mining and recommender systems, by proposing the following general lines of work:

- **Building argumentative corpora suitable for exploitation by recommender systems**, i.e., composed of ratings between users and items, and argumentative texts. To this end, we propose to explore case studies with different discussion forms, debate structures, and argumentation levels. Argument mining techniques will be applied to automatically process the input data for building the corpora.
- **Designing, implementing and evaluating argument-based recommendation methods**. We propose to investigate methods belonging to the three identified types of approaches: prefiltering, filtering and postfiltering. To evaluate the developed methods, we plan to conduct online studies, measuring user-oriented metrics in interactive environments, such as those of conversational systems.

In this paper, we depict the hypothesis and goals of the thesis that will guide the previous work lines. Before, we survey related work on argument mining and argument-based recommender systems, and present the case studies that will be addressed in the thesis.

2 RELATED WORK

2.1 Argument mining

The understanding and modeling of arguments are topics of human concern and thought since the Ancient Greece [31]. According to Aristotle, argumentation is the ability to consider the elements that are useful to persuade someone on a given issue, attending to logical (logos), ethical (ethos) and emotional (pathos) aspects. Hence, the Greek tradition focused on rhetoric, which is understood as the art of arguing and is based on discourse and persuasion figures, as well as gestures, mimics, and other types of non-verbal communication.

Since then, in Linguistics, the fundamental structures of human language, theories and models of representation of argumentation have been studied [35]. In the 20th century, Computational Linguistics (CL) emerged as a research field confluent with Artificial Intelligence, with the clear purpose of studying language using corpora and computers. Its multidisciplinarity motivated the formation of Natural Language Processing (NLP) as a specialized field in the 1980s, concerning the interactions between human and computers, and focusing on how to automatically process, analyze, and exploit large amounts of natural language content. In the last 20 years, the

field has shown extraordinary advances and real large-scale applications, due to the huge increase of raw data in the Web, and the appearance of data-driven, statistical and (deep) neural networks models [24, 52].

At the intersection between CL and NLP, Argument Mining aims to extract arguments and their relations from natural language texts, and provide structured, machine-processable argument data. Since its definition by Mochales Palau and Moens [40], advances have been made in the field, not only by defining and formalizing the main tasks –*detection of arguments* [27], *identification of argument components* (mainly premises and conclusions) [40], and *recognition of argument relations* (e.g., arguments for or against each other) [26]–, but also by analyzing the results from a data-driven perspective [9], exploring data-independent classification approaches [18], proposing flexible and extensible frameworks for processing social network data [37], and developing emerging data-driven technologies [52].

Argument detection consists of the segmentation of a text into argumentative units, separating it into argumentative and non-argumentative parts, and identifying the boundaries of the former, in one or several sentences [42]. The *identification of argument components* consists of the classification of argumentative units, distinguishing between premises and conclusions, as well as different types of evidences [49] and assertions like supporting, opposing or proposing [32]. Lastly, the *recognition of relations* between arguments consists of the identification and possible classification (e.g., support, attack) of links between pairs of argument components, forming argument trees or graphs (cf. abstract argumentation theory [4, 12, 22]). In general, these tasks have been addressed separately as classification problems using machine learning techniques [40, 42], although recently, they have been treated as "sequence labelling" problems addressed through neural network models appropriate for certain NLP tasks, such as grammatical and syntactic analysis, in particular part-of-speech tagging and dependency parsing [23].

One of the main challenges faced by current argument mining approaches is the scarcity of annotated argument corpora that serve as training and test data [35]. To address this limitation, recent efforts have been made on the creation of datasets of different sizes in various domains, such as AIFdb [34] –an implementation and repository of databases (e.g., AracuriaDB with newspaper editorials, parliamentary records, court summaries, and panel discussions; MM2012a with BBC Radio 4 transcripts, etc.) following the Argument Interchange Format, AIF–, The Internet Argument Corpus, IAC [58] –a set of political discussions in Internet forums–, the ECHR corpus [39] –a set of documents extracted from legal texts of the European Court of Human Rights, ECHR–, and The Argument Annotated Essays Corpus, AAEC [53] –a corpus of persuasive essays–, among others.

In addition to algorithmic solutions and datasets, to address argument mining tasks, progress has been made in the development of tools that allow creating, integrating and exploring structured argumentative data, such as collaborative argumentative graph editors (e.g., Agora,[1] Argunet,[2] DebateGraph[3] and Rationale Online[4]) and argumentative text annotation platforms (e.g., Araucaria[5] and OVA[6]).

In the thesis, we plan to make use of some of the above methods, tools, and corpora to conduct the argument mining tasks needed to implement and evaluate the developed argument-based recommendation methods.

2.2 Argument-based recommender systems

In parallel to the work done in argument mining, argumentative recommender systems have been investigated independently. Inspired by the taxonomy of context-aware recommender systems given by Adomavicius and Tuzhilin in [1], we propose a categorization consisting of three types of argument-based recommendation approaches, namely *argumentative prefiltering*, *argumentative filtering*, and *argumentative postfiltering*.

Prefiltering methods, in general, extract argumentative information from textual content which is subsequently used by recommendation algorithms and recommendation explanation techniques, not necessarily based on an argumentative logic. Citation tagging of scientific articles can be considered as one of the precursor research lines of argument mining [35]. Its use for article recommendation based on the reasons underlying the citations –e.g., motivation, contextualization, hypothesis, objective, improvement, limitation, etc.– is a representative application of prefiltering methods [21]. Another example is the recommendation of legal texts that relate to certain facts or legal aspects [54]. *Filtering methods*, in contrast, start from data (i.e., user preferences, item attributes) described in argumentative structures and, in general, either use an argumentation engine –e.g., based on Defeasible Logic Programming, DeLP [25]– to generate recommendations [14, 15, 56], or incorporate argumentative information in classic recommendation algorithms, such as rule-based algorithms [8] or hybrid algorithms that combine content-based and collaborative information [48, 50]. Lastly, *postfiltering methods* mainly focus on the generation of argumentative explanation of recommendations [20, 44, 59], although there are examples where argumentative information is used to rerank independently generated recommendation lists [7, 16, 17].

Most of the proposed systems are based on DeLP frameworks [14, 25], which allow modeling the state of the world even if it has inconsistent and potentially contradictory knowledge. These frameworks are built upon argumentative knowledge modeled as defeasible logic program $P = (\Pi, \Delta)$, where Π and Δ stand for strict knowledge and defeasible knowledge (i.e., tentative information that can be used as long as nothing is posed against it), respectively [15]. The Π set involves strict rules of the form $P \leftarrow Q_1, \ldots, Q_k$ and facts (strict rules with empty body) —e.g., $good\_rating(Movie) \leftarrow rating\_movie(Movie) > 3$—, whereas the Δ set involves defeasible rules of the form $P \prec Q_1, \ldots, Q_k$, –e.g., $recommend(Movie, User) \prec good\_rating(Movie), likes\_by\_top\_genre(Movie, User)$–. A user's

[1] Agora collaborative argument visualizer, http://agora.gatech.edu
[2] Argunet argument map editor, https://sourceforge.net/projects/argunet
[3] DebateGraph argument network visualizer, https://debategraph.org
[4] Rationale argumentative map editor, https://www.rationaleonline.com
[5] Araucaria argument annotator, http://staff.computing.dundee.ac.uk/creed/araucaria
[6] OVA argument analyzer, http://ova.arg-tech.org

profile is then composed of a set of rules and facts, where rules are defined in terms of literals, and the derivation of rules results in the construction of arguments. Subsequently, the generation of recommendations consists of running a DeLP program, which uses the constructed arguments to filter or rerank the items that will be presented to the users. In this context, DeLP enables the understanding of user preferences and facilitates the provision of argumentative recommendations [6]. However, it requires the creation of the argument knowledge base, which has been done manually in most cases [16] or has been limited to automatic simple conversions of relational databases to rules and literals [5].

Another majority group of argument-based recommendation approaches has centered on the provision of argumentative explanations of recommendations, independent from the underlying filtering algorithm [28, 44, 48]. In this case, arguments are mainly described as relationships between user preferences and item attributes, and sometimes are based on beliefs, desires and intentions [57].

After surveying the scientific literature, we found out that techniques and models developed in argument mining have barely been exploited in the context of recommender systems. However, automatic processing of text corpora to extract arguments, argument components, and argument relations would allow enriching the data commonly exploited by recommendation methods, e.g., user reviews in e-commerce applications and personal posts in blogs and social networks. Moreover, research papers on argument-based recommendation have presented preliminary approaches evaluated non-rigorously in a limited set of domains —e.g., movie [6], music [5] and e-learning [28, 50] recommendations—, and without using medium/large-scale argumentative annotation databases. These issues will be addressed in the proposed thesis, thus mitigating the gap between argument mining and recommender systems.

3 CASE STUDIES

Narrowing the scope of the thesis, and in addition to the traditional e-commerce domain —represented by the well-known Amazon product review dataset [45]—, we propose to address 3 related contexts of e-participation: i) citizen proposals and associated comments on participatory budgeting electronic platforms (with structured conversations, well delimited, focused on particular proposals, and a relatively high degree of argumentation), ii) political discussions in online social networks (unstructured, with open topics and limited argumentation), and iii) debates in transcripts of parliamentary sessions (moderately structured and highly argumentative).

E-participation has been defined as the use of information and communication technologies (ICTs) to broaden and enhance political participation by enabling citizens to connect with each other and with their elected representatives [38]. It represents one of the main strategies of open government, which seeks to strengthen democracy through a more transparent, collaborative and participatory government [33].

Addressing the aforementioned e-participation contexts is of interest and relevance for two main reasons. First, the textual contents generated in e-participation tools have a high degree of argumentative information, which has not received attention in the argument mining field, but has an important value and utility for all the stakeholders involved. Identifying (automatically) the reasons associated with citizens' opinions, the facts that support government actions, or contrasting and comparing political statements, among other issues, is fundamental for the data analysis and mining tasks that assists in decision and public policy making.

Second, current e-participation tools have very limited information search and filtering mechanisms, generally based on keywords and absent of customization features [19]. However, the amount of content in such tools is very large, and accessing relevant information by a user can become a very tedious, sometimes overwhelming, task. This justifies the need of incorporating recommendation functionalities into the tools. Moreover, as in other domains —e.g., e-commerce and entertainment—, the provision of (well-argued) recommendations in such tools would increase the likelihood of greater participation and satisfaction of citizens and other actors, as well as a very valuable support for different decision making tasks in the contexts addressed: selection and implementation of citizen proposals, analysis of opinion and criticism towards the government, verification of compliance with electoral programs, among others.

To address the proposed case studies, in addition to other resources, we will work upon own implementations, datasets, and experiments already developed and published [10, 11, 19, 30].

4 HYPOTHESIS AND RESEARCH GOALS

The thesis is proposed upon the **hypothesis** that the exploitation of argumentative information can lead to significant novelties and improvements in the user's experience with recommender systems. Argument-based recommendations could be particularly useful in certain decision making tasks, and generating explanations and interactions in an argumentative way could increase the system accountability and transparency, and consequently improve the user's satisfaction, trust and loyalty.

Taking the above hypothesis as a starting point, and motivated by the considerations presented in the introduction, the thesis will address the following **research goals**:

- **Comprehensive analysis of argument-based recommender systems**. We will conduct a survey of the state of the art that will mitigate the gap between argument mining and recommender systems, by analyzing general approaches, existing tools and resources, and open research lines. The survey could represent a major reference to increase interest and research on the topic, and guide in the design, implementation and evaluation of new argument-based recommendation solutions.
- **Creation of new argumentative corpora**. We will build corpora semantically annotated with argumentative information for the e-commerce and e-participation domains. The corpora will be valuable resources for researchers and practitioners in a variety of tasks that could go beyond the extraction of arguments and generation of recommendations.
- **Development of novel argument mining techniques**. We expect to implement automatic argument extraction techniques that, unlike existing methods in the literature, will operate on detailed representations of argument components

and relations. As a complement of these techniques, we will generate general-purpose linguistic resources, such as argument taxonomies and connectors, and opinion lexicons.

- **Proposal of novel argumentative recommendation methods**. Differently to previous work, we will explore recommendation algorithms that exploit argumentative information before, during and after their filtering processes. The comparison of the developed methods with other existing methods will be done empirically. To this end, we expect to use both well established and new evaluation methodologies and metrics. In particular, we could consider online studies focused on evaluating aspects such as user satisfaction and trust, and system transparency.
- **Improvement and enrichment of e-participation tools**. The use of argument-based recommender systems in e-participation contexts may entail relevant contributions. For instance, it would allow developing e-participatory budgeting platforms with better mechanisms for the collaborative creation of citizen proposals and the access and exploration of existing proposals and their comments; it would allow finding controversial and false (doubtful) information posted on online social networks; and it would allow performing decision making by searching and comparing political speeches from parliamentary sessions.
- **Analysis of opinion and debate in e-participation**. Aside from recommendations, the argumentative information extracted from the corpora could give rise to a wide range of studies on opinion and argument analysis in e-participation, coping with topics, discussion dynamics, and levels of (dis) agreement, among other factors.

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