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Visualization Functions in Argumentation Representation Software

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Abstract

In the historical development of argumentation as a scientific direction and applied field, a number of ways of its visual representation have been developed. In the middle of the 20th century, within the framework of the theory of argumentation, in addition to the logical, rhetorical and computational concepts used since ancient times, new concepts were formulated that shaped the basis for the representation of argumentation using software. First of all, this foundation was laid by researchers who put forward new approaches to its formalization (Stephen Toulmin, Phan Mihn Dung). Since the beginning of the 21st century, the dynamics of informatization of scientific activity and education have led to the development of software designed to represent argumentation and evidence-based reasoning. Both textual and graphical tools are used in the software to visually represent argumentation for solving various tasks depending on the purpose of using the software. We examine the possibilities of the existing software for visualization of argumentation and identify its features and main functions, which open a possibility for a more justified and goal-oriented selection of appropriate tools for the effective solution of various tasks. The article is based on the results of a talk and discussion at the All-Russian scientific conference "Scientific service on the Internet" in 2023.

Keywords: argumentation, representation, visualization, software, argumentative schemes.

Introduction

Argumentation is the intellectual activity of rational agents to substantiate or refute some statements with the help of others in the form of reasoning, usually presented in dialogue. Argumentation is always a purposeful, instrumental and social-communicative activity, carried out using any expressive means, including natural or formal language, as well as gestural, graphic, audio-visual, and, depending on the purpose, implemented in different rhetorical styles and genres [1, 2]. Expressive means of representing argumentation perform the mediating function of transmitting and decoding the messages in which it is contained, and constitute its integral part. Their choice is subject to the properities of the argumentation itself in relation to the practical goals for which rational agents decide to use it. For this reason, the representation of argumentation is an integral element of either a methodology for solving specific problems in various fields of knowledge, for example, in decision theory [3], computer science [4], media communications [5], and pedagogy [6], or the reconstruction of argumentation, as, for example, in logical or mathematical proof [7], rhetorical [8] or pragma - dialectical approaches to argumentation [9]. In the latter case, the representation of argumentation is subordinated to the solution of a single class of problems of analysis of argumentation and reasoning, albeit in different ways, and acts as a special section of the subject of study of the theory of argumentation. In contrast, in the first case, various methods of implementing representation are rarely isolated from the general methodology for solving heterogeneous problems, except perhaps in the course of learning to solve problems of this type.

We focus on discussing the visualization of argumentation as a type of its representation, reconstruction or analysis using text, formulas, graphs, diagrams, flowcharts, images, etc., in contrast to visual argumentation, where pictures or video sequences are a specific way of presenting it, but not reconstruction or evaluation [10]. We are not considering visual argumentation here.

Argumentation is most often relied upon for cognitive or social purposes in situations of disagreement between parties, providing arguments to defend or criticize a point of view about the truth of a proposition or about what course of action to take in a given situation. Overcoming differences of opinion through persuasion, informational or emotional-psychological influence on others, considered as a product or as a process of argumentation, is a technical technique for eliminating, or, conversely, polarizing disagreements [11, 12], for consolidating agreement and identifying deep disagreements [13], and can also be part of the task of establishing social control [14], including control of trust [15] and social status of the parties [16].

In the representation of argumentation intended for its reconstruction, the structure and procedure of argumentation, as well as argumentation as a form of its presentation, can be visualized in two ways, depending on which element is taken as atomic. Visualizing argumentation involves visualizing reasoning or visualizing discussions. In the first case, its atom is an inferred conclusion or a piece of reasoning as an ordered set of statements that make up molecular chains of reasoning, positions of the parties or rounds of a dispute. The ordering of (chains of) reasoning is carried out on the basis of arguments-specific relations between its atoms, such as relations of support or criticism. In the second case, we are talking about visualization of discussions, debates, etc., and the entire multilateral discussion, dialogue or speech, considered as an ordered set of arguments, reasoning or other moves of the parties, such as questions, etc., is subject to reconstruction, none of which acts as an independent element of this argumentation, and their ordering is carried out on the basis of various relations, both specific to the argumentation and not specific to it, such as rounds of discussions, positions of the parties, etc.

There are two approaches to visualizing argumentation, normative, when its representation is simultaneously not only its reconstruction, but also its assessment; and descriptive, when it is reduced exclusively to representation, and the connection between representation and evaluation, if necessary, is established in a special way. The normative representation of reasoning is called formalization, and the term “visualization” is assigned to their descriptive representation and is more characteristic of the visualization of discussions.

In the development of visualization of argumentation, three stages can be distinguished: ancient, from antiquity to the mid -19th century, classical, from the mid -19th to the end of the 20th century, modern, covering the first decades of the 21st century. The ancient stage is characterized by formalization - the historical first way of visualizing reasoning, which has come down to us in three forms. These are geometric constructions as an integral element of proofs “with the help of a board and dust”, such as the proof of the Pythagorean theorem in Plato’s dialogue “Meno”, which is a drawing; elements of formalization of inferences, such as the logical square of oppositions, visualizing formal relations between simple categorical propositions, which allow one to build and test elementary demonstrative inferences; as well as elements of formalization of calculations associated with the introduction of numeric and alphabetic symbols for their representation.

Formal relations characterizing inferences, such as contradiction, opposition and subordination, were first described by Aristotle in the 4th century BC. e. in his treatise “Prior Analytics”, and their first visualization is found in Apuleius in 2 AD. in his treatise “The Golden Ass”

[17]. Another important contribution of Aristotle to the normative visualization of reasoning was the use of literal symbols to represent non-logical terms in the logical form of inference, which many see as the first step towards the introduction of subject variables. A significant contribution to the textual visualization of reasoning was made by medieval Arab-Muslim thinkers, who developed symbolic techniques for recording computational inferences.

Medieval Latin scholastics widely used textual and diagrammatic methods for visualizing demonstrative inferences, such as: diagrams of genus-species relations (Porphyry's tree), types of quantified terms (tables of suppositions), figures and modes of the simple categorical syllogism, etc., as well as textual representations, including poems for memorizing logical rules and checking the correctness of inferences. Some of these techniques for visualizing reasoning are still used in logic today.

Examples of the development of visualization of discussions at the ancient stage include text classifications of speeches, rhetorical canons, figures of speech and techniques for creating and delivering speeches [18], taxonomies of topoi as dialectical figures of reasoning, proposed by Aristotle and Cicero in their treatises called “Topics”, as well as classification of fallacies in reasoning, the first of which was compiled by Aristotle in his treatise “On Sophistic Refutations”.

In the second half of the 19th century, an important contribution to the formalization of reasoning was made by George Boole, who put forward the idea of using algebraic representation and mathematical methods to reconstruct logical inference [19]. At the beginning of the 20th century. Gottlob Frege and Charles Peirce independently proposed fundamentally different ways of recording logical reasoning, respectively, schematic, which gave rise to one of the most common methods of formulaic representation [20], and diagrammatic, the merits of which were appreciated only at the end of the 20th century. [21]. Frege's other important contribution was the triad, which added the third instance of sense to the previously two-element semantic model of sign-meaning. This opened up two perspectives at once: visualization of the assessment of reasoning using semantic formalisms separately from syntactic formalisms of representing conclusions and evidence; and visualization of discussions in an instrumental manner based on various kinds of meaningful relationships, not necessarily related to the characteristics of reasoning used in solving problems in different fields of knowledge. The implementation of both perspectives constituted the classic stage in the development of visualization of argumentation. In the 20th century a number of new logical notations appeared, for example, the Polish prefix notation, as well as new ways of visualizing logical conclusions and proofs, for example, using abstract computing machines (Post, Turing), as well as ladder circuits. Such methods of representing reasoning influenced the development of programming in computer science, in particular, the development of programming languages. In the middle of the 20th century, examples of the implementation of both perspectives are such representation methods that have become firmly established in scientific and educational use, such as graphs, tables, models, frameworks, etc. in line with the first of them, as well as mapping using flowcharts or diagrams, up to mind mapping - in line with the second.

Visualization as a way to represent argumentation using software

By the beginning of the 21st century, the processes of informatization generated by the development of the information society gradually covered all aspects of life and areas of human activity. Argumentation was no exception. This led to the beginning of the development of software designed to solve practical problems of planning, critical discussion, analysis and evaluation of project proposals, modeling and representation of argumentation, teaching critical thinking skills, etc. The main function of such software is the representation of argumentation.

In previous studies, when analyzing the software, we focused on the theoretical foundations that are laid down in its implementation, as well as important groups of criteria that must be taken into account when developing software designed for modeling and representing deliberative argumentation [22, 23]. However, the visualization function was not considered in detail. Only in a pilot study did we examine the capabilities and features of some software applications for constructing argumentation maps [24].

Based on our research, similar software can be grouped into the following categories based on their main purpose:

— modeling of argumentation;
— visualization of critical and deliberative reasoning;
— mapping reasoning and mental activity (mind-mapping).

In applications belonging to various categories, visualization of argumentation pursues its own goals and, at the same time, is implemented by various means. Some aspects of visualization implementation are considered in a fairly extensive research literature, published during the period of maximum dynamics in the development and use of this software. Visualization receives attention only in some studies that consider the use of software to solve a wide range of problems related to the representation of argumentation. At the same time, various aspects are considered, one way or another related to the possibilities of visual representation of argumentation.

A study of the impact of tools for constructing representations of evidence-based models on the processes and results of collaborative learning examines three types of visualization of problems in the field of health care: graph, matrix and text [25]. Based on the analysis of the results of the conducted pedagogical experiment, it was found that when analyzing scientific texts, the most effective for perception and understanding is the graph representation, followed by the matrix and text ones.

Compendium software application for educational purposes for knowledge visualization are considered by Buckingham Shum and Okada [26]. As an important aspect, they note the possibility of creating maps automatically or manually, which is necessary both for teaching argumentation and for identifying errors in argumentation made during the analysis of texts.

The authors of another study [27] consider software systems from the point of view of the effectiveness of argument visualization tools.

Bart Verheij, in his study of software to support solving argumentation problems for lawyers [28], focuses on the visualization and evaluation of arguments in terms of their consistency with respect to counterargumentation, clarifies the expressive capabilities of mapping arguments using flowcharts and the possibility of using text for markup.

Another area of use of argumentation visualization systems is joint discussion in project and other collective activities. Such activities are characterized by the development of the best solution based on an analysis of the discussion, and more specifically, on the basis of an analysis of the arguments put forward during the collective discussion. For example, in their article, Tzagarakis and Karacapilidis note the need to use expressive computer visualization tools to highlight markers of the argumentative discussion process in the medical field, which will formalize the discussion for a better understanding of the opinions of participants and a more effective choice of the optimal solution [29].

In his article, Benetos considers argumentation representation software as tools for analyzing texts containing argumentation [30]. As an application, he suggests using them in the educational process for generating ideas, planning essays for various genres of argumentation, drawing up diagrams and structuring text. The article discusses several applications. For example, Rationale, which is intended to be a visual representation of argumentation. He noted the use of three types of maps (tools for analyzing argumentation): grouping, reasoning and advanced reasoning. Grouping supports combining ideas, while reasoning and advanced reasoning allow designing an argument. Another app reviewed, Endoxa Learning, is for graphical argumentation diagramming. It is intended primarily for the development of argumentation, reasoning and critical thinking in educational institutions. The author also reviewed the Kialo web platform, which provides an environment for collaborative structured conversation and debate. Kialo is based on peer feedback and allows to collectively analyze the features of constructing an argument and make adjustments. In Kialo, as in Rationale, visualization is implemented as free construction of argumentation graphs by the user. As Benetos notes, this platform is not only intended for use in the educational process, but can also be used in various contexts to support decision making.

Another software, C-SAW, designed as a web-based application, is focused on developing and structuring texts. Argumentative schemes are generated automatically in accordance with user actions and cannot be arbitrarily changed. The visualization is implemented in a linear text form and reflects the process of sequential text creation.

A fairly established area of application of IT technologies is the electronic participation of citizens in public discourse on socially and politically significant topics. This area also includes public debates and discussions that in modern society are held on the Internet on specially designed platforms. At the same time, an important part of this direction is the analysis of deliberative argumentation. In the context of research in this direction, various software systems are considered in the context of visualization of deliberative processes. A feature of such discussions is the large number of participants who, as a rule, are not experts in the field of argumentation. Therefore, both for participants and for those specialists who analyze public discussions, it is important to use modern means of visualizing dialogue interaction. Anna De Liddo and Simon Buckingham Shum, noting that dialogues on the Internet proceed rather unevenly over time, come to the conclusion that this significantly affects the adequate perception of the logical structure of disputes, which impedes both the quality of user participation and the effective assessment of the state of the debate. In this regard, they propose to use applications with linear multi-threaded or network animated visualization of argumentative communication [31]. At the same time, animation should have a positive effect on the emotional state of participants in the deliberative process. Noting the importance of analyzing and developing strategic stages of policy formation, the authors of another article [32] talk about the need for the use of software platforms for visualizing argumentation by experts and influential politicians, both to better understand complexly structured debates and to be able to analyze them effectively. However, considering the WAVE web platform developed for this purpose and the Debategraph software integrated into it, they do not address any specific features or characteristics of argumentation visualization. Another study is devoted to the visualization of argumentation during public deliberative communication [33]. Considering the use of VisArgue software, the authors aim to use visualization tools to develop social deliberative communication skills of participants in these processes. Therefore, in large online debates and public discussions, visualization should, in their opinion, be represented by a map that graphically displays the relationships between all the participants indicated on it. For the purpose of rapid analysis of the deliberative process, fully automatic visualization in real time is important for participants, when the visualization reflects the progress of discussions in a synchronized manner, and this determines the choice of appropriate software. Another article focuses on the ArgVis software application as an argumentation visualization tool that encourages the development of structured dialogues without requiring users to have argumentation skills [34]. They note that the visual representation of arguments and their relationships in ArgVis, on the one hand, increases the expressiveness of dialogues, and, on the other hand, facilitates the analysis and understanding of user dialogues. An important feature of graphical representation is the ability to change the scale of the display, which helps users focus on certain parts of the arguments in rather complex graph designs. Visualization is also important for researchers of argumentation processes in public and political debates, as noted in an article that presents the results of a study of public debates on climate change [35]. In it, the authors propose to use the DebateGraph and Cogitant applications together as a tool for analyzing and visualizing argumentation. This combination is aimed at effectively studying the accumulated results of long-term, distributed and complex argumentation processes based on the construction of argumentation maps. Their goal is to support stakeholders in deliberative processes to improve their understanding of the implications of new issues.

Building on cutting-edge research, Benn and Macintosh aim at developing an argumentation visualization tool to support e-participation and deliberative communication on the Internet [36]. At the same time, the most important tasks for researchers are the following: analysis of unstructured text from various sources of information to reconstruct formal arguments; improving the understanding of communication participants about what critical questions need to be asked to determine the validity of the statements made; identification by participants of significant and pressing issues in the dynamic flow of information generated during discussions and debates. To solve these problems, visualization must be based on mapping argumentation over time. A team of researchers proposes a method for using argument visualization software applications to support participation and online discussion, focusing on the interconnection of argument map elements, importing/exporting argument maps, and editing map layouts.

When analyzing political discussions using software, the authors of another study consider the interactive nature of graphical representation and the ability to edit argumentative maps to be an important aspect [37].

Al-Shehhi's dissertation research is devoted to the consideration of forms and methods of visualizing decision support and knowledge generation, implemented in appropriate software [38]. She identifies the main styles of visual representation of argumentation: linear (text), multi-threaded (text), graph (graphic), container (graphical), matrix (graphical).

In article [39], the authors divide all applications into two categories according to the type of visualization - graphic, through linking nodes with special argumentative connections, and text, through hierarchical grouping.

A review of the extensive literature on argumentation systems [40] examines features of argument diagram visualization (e.g., textual versus graphical), argumentation visualization style (linear, parallel, graph, container, matrix), graphical style layout control (system or user controlled).

In another comprehensive review of argumentation visualization software, the authors examine those available in the first decade of the 20th century. applications in terms of their effective use in teaching critical thinking and argumentation skills [41]. Therefore, they focus their attention on software created specifically for educational purposes (Belvedere, Convince Me, Questmap, Reason!Able). Analyzing the various features of the tools under study, they highlight the Belvedere software. Their research shows that the best results were achieved by those students who used a matrix representation rather than a graph representation. In turn, a graph representation is more efficient than a text representation.

Considering the current state of general techniques, as well as specific software systems for solving problems within the framework of abstract argumentation, structured argumentation and approaches to visualization and analysis of argumentation, F. Cerutti et al. note that for the analyzed tasks within the framework of formal approaches to the representation of argumentation, the most appropriate is graph visualization [42].

In their fundamental article, the authors describe the development of argumentation and argumentation theory in historical retrospect [43]. Noting the modern turn to the formal approach and information and communication technologies, they focus on the differences in styles of graphical representation of argumentation in various software applications (Hermes, Zeno, Belvedere, Araucaria).

Graph visualization was implemented by the developers of the DAQAP web platform (Defeasible Argumentation Query Answering), which is both an auxiliary argumentation system and an automatic argumentation system, which allows automatic constructing of arguments and the argumentation process based on a knowledge base, and also visualizing this information in the form of graphs in a user-friendly form, supporting analysis of the argumentation process using non-monotonic formalisms logic programming based on defeasible models (DeLP) [44].

In their study, the authors propose an argumentation graph construction method that includes an ontology to describe the argumentation structure of scientific articles, a deep semantic annotation process, and mapping protocols to transform annotation results into a graph structure using Neo4J [45]. Based on the testing of their development, they note that the graph representation of argumentation can be effectively used for visualizing argumentation and strategic reading of scientific articles.

Recently, artificial intelligence technologies have been used to study argumentation. This kind of research is based, among other things, on a graph representation of argumentation. Thus, K. Block et al. in their study consider the problem of clustering argument graphs to study structures that facilitate the interpretation of argumentation. In this case, the graph representation of the argumentation is taken as an example of using the OVA application [46].

In general, we can conclude that in addition to the main types of visualization (text and graphic), the software also implements various styles (Table 1):

Table 1. Types and styles of visual representation of argumentation in software

Style	**View**
linear	text
multi-threaded	text
graph	graphic
container	graphic
matrix	graphic

At the same time, when implementing the graphical method, the nodes are linked with special argumentative connections, and the textual method assumes hierarchical grouping.

Basic features of argumentation visualization in software

In our own practice, both for research (studying the representation of argumentation, as well as a wide range of critical and deliberative reasoning) and for educational purposes (teaching argumentation), we use several of the most common software applications. Their comprehensive study allows us to consider the possibilities of visualization depending on various factors.

For example, the web-based application OVA (http://ova.arg-tech.org), which replaced the Araucaria application, is intended for constructing argumentation maps for the purpose of analyzing and modeling argumentation in a text.

The features and advantages of the software application in question are used in teaching argumentation and critical thinking [47]. The capabilities of OVA allow it to be used quite widely - both for educational and applied purposes. For example, this application was used to visualize a high-profile public debate in which dozens of influential people participated over the course of about six months. As a result, it allowed to show how visualization made it possible to reveal the implicit deep disagreement between the parties [48].

The construction of argumentation maps in OVA proceeds as follows. First, the user places the analyzed text on the left side of the interface desktop, placing the text itself or a web link to it there. Then, by highlighting fragments in the analyzed text that are understood by the user as a claim to be defended or refuted (thesis), arguments in support of it, objections or counterarguments, on the right side of the desktop these fragments are displayed by the corresponding atomic elements of argumentative markup, forming an argumentation map, where meaningful fragments of the text appear inside its cells are the vertices of a graph, the edges of which symbolize the connections between them. To the statements explicitly expressed in the text on the left side of the desktop, which are displayed in blue cells, the user can independently add new statements if they believe those are implicit in the reasoning being mapped. User-added snippets appear in gray cells. The user can reconstruct connections within chains of reasoning based on one of nine formal ontologies, each of which contains a specific set of argumentation schemes (Walton presumptive inference, Rutgers SALTS, Cornell, Dundee illocutionary, Second order illocutionary, Basic conflict, Extended Conflict, Deductive inference) (Fig. 1). The choice of ontology and schemes sets the style of the argumentation map, according to which the blocks are connected to each other by the relationships provided for by the corresponding argumentation schemes (Fig. 2). A special feature of the OVA application is the ability to add your own argumentation schemes (within the framework of implemented formal ontologies), which significantly enriches the expressive capabilities of visualization.

Another advantage of the OVA application is the ability to download a visualization map in JSON format, when you need to return to the analysis of the mapped text later, or in PNG format, which allows you to use the resulting argumentation maps in the educational process and for methodological purposes.

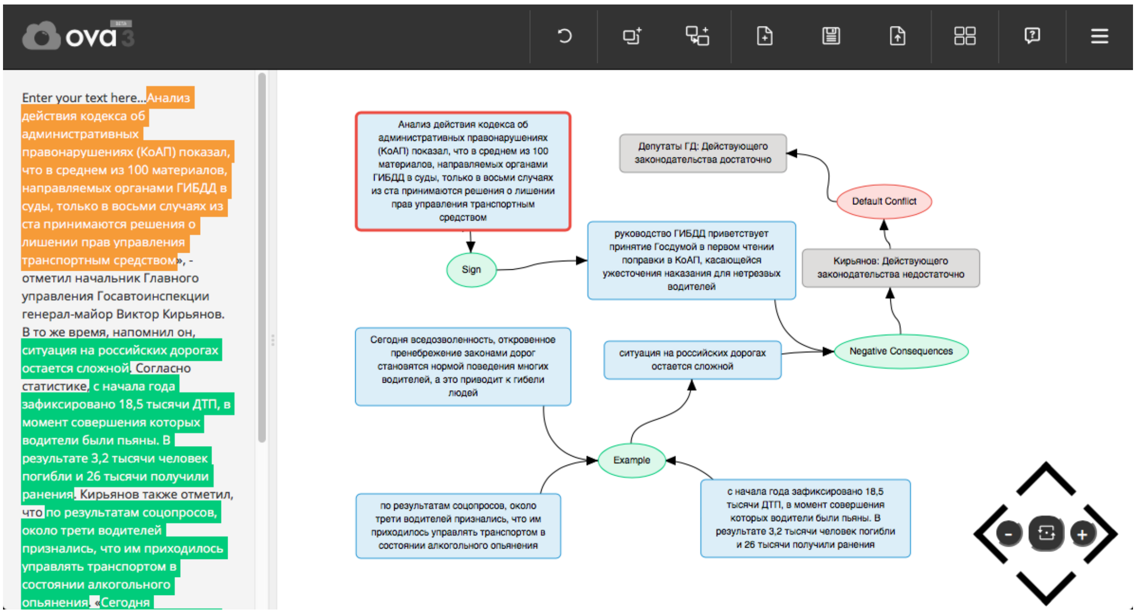

Fig. 1. OVA application interface with marked up text and graph visualization

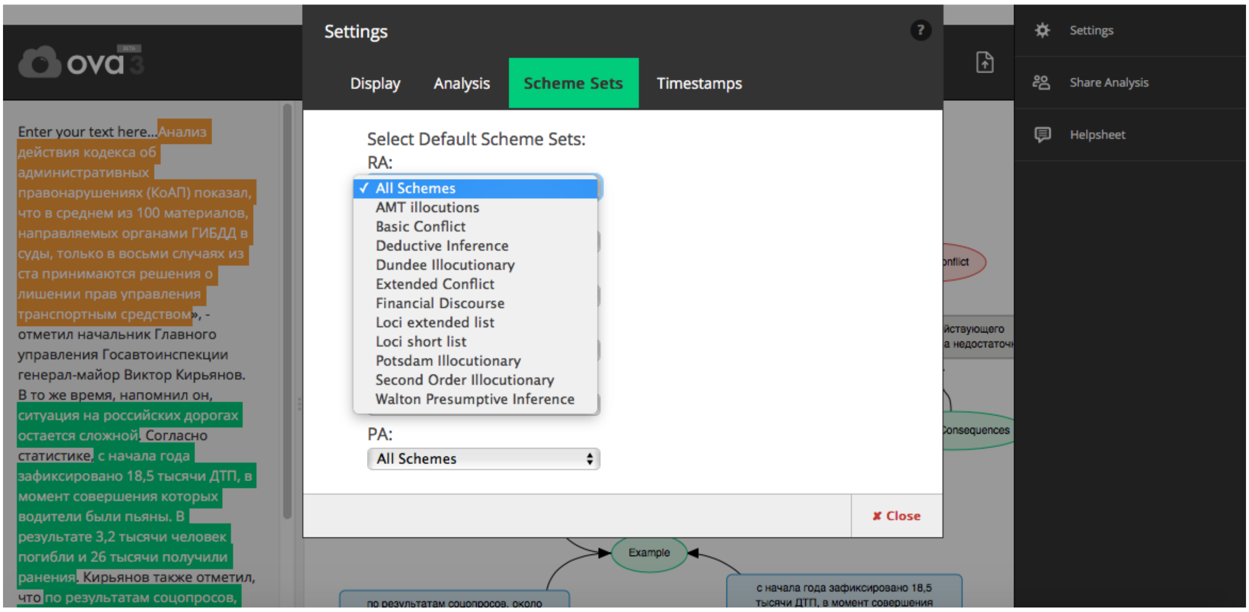

Fig. 2. Selecting an argumentative scheme for atomic elements and connections in the OVA application

In another software application, Rationale (https://www.reasoninglab.com/rationale/), which replaced Reason!Able, the relationships between reasons in chains of reasoning are limited to support, criticism, and counterargumentation relationships, and argumentation schemas are not implemented. This allows to flexibly use Rationale to generate texts containing argumentation designed to solve different problems, in the spirit of design thinking, as well as to make a multifactorial assessment of the effectiveness of argumentation. Visualization of argumentation in Rationale is implemented in its intuitive mapping using existing theories reflected in standard textbooks on argumentation. As in the OVA, the Rationale user has the ability to edit text within blocks on the map. In Fig. 3 shows the text visualization in Rationale from the previous example.

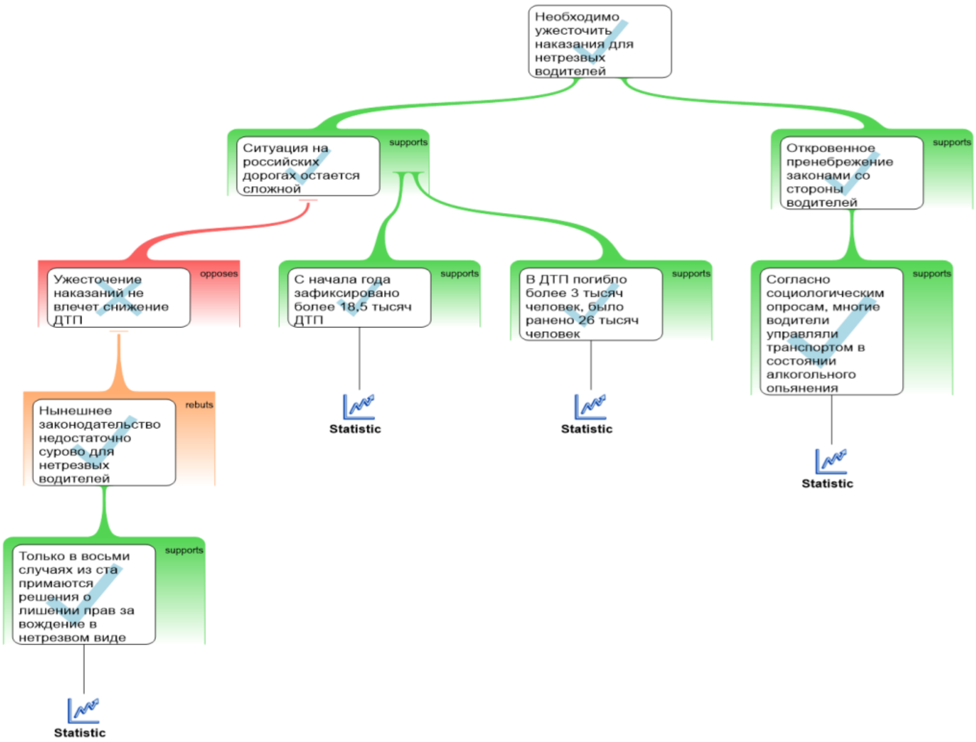

Fig. 3. Visualization of argumentation in the Rationale application

Rationale application was conceived as a visual constructor of texts of different genres, oriented towards the apparatus of argumentation - reviews, essays, critical reviews, etc., for which appropriate templates are provided (Fig. 4), but it also turned out to be very convenient for reconstructing and analyzing argumentation. One of the significant disadvantages of Rationale is that it is distributed on a commercial basis with payment outside of Russia.

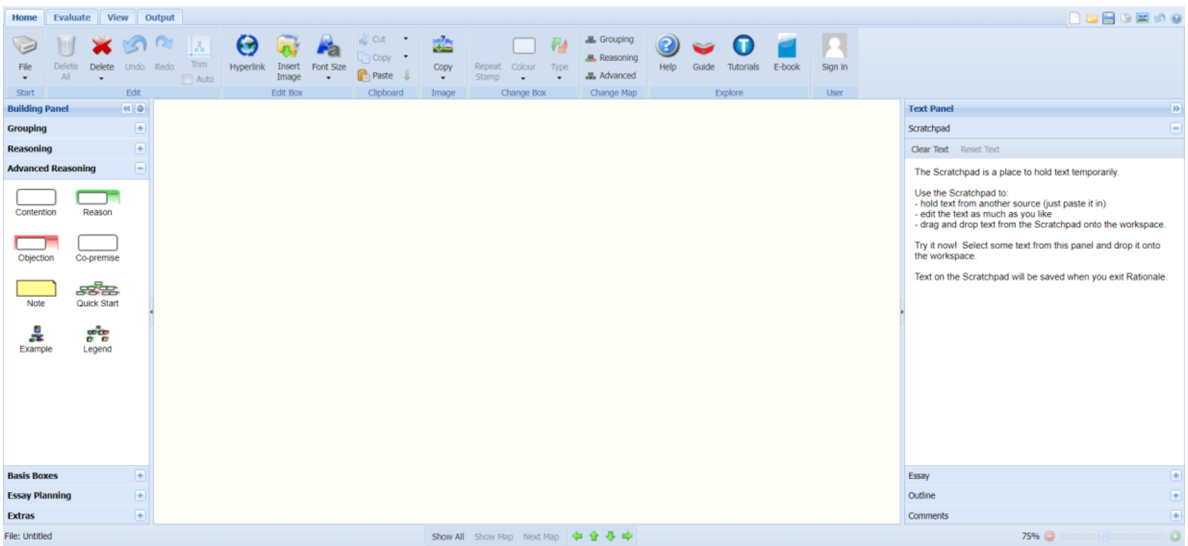

Fig. 4. Rationale application interface

Another widely used application is Carneades (https://github.com/carneades). This software implements an integrated approach in which:

— the posted text is first subjected to manual argumentative marking; then properties and relationships are specified for statements, premises and arguments (Fig. 5, 6);

— after this preliminary preparation, a text representation of the argumentative graph (linear representation) is created (Fig. 7);

— after checking the correctness of its construction, a graphical representation (argumentation map) is automatically created in the form of a network-oriented graph (Fig. 8).

At the same time, when the properties and connections of argumentation elements change, the visualization structure (both text and graphic) is automatically adjusted. To make corrections to the graph, you need to make changes to the argumentative markup.

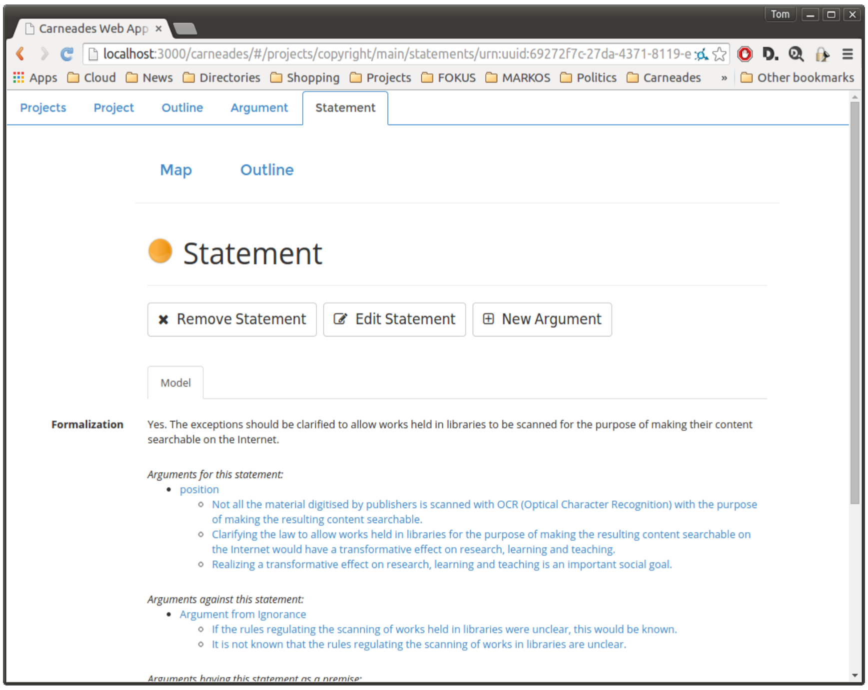

Fig. 5. Setting statement properties in Carneades

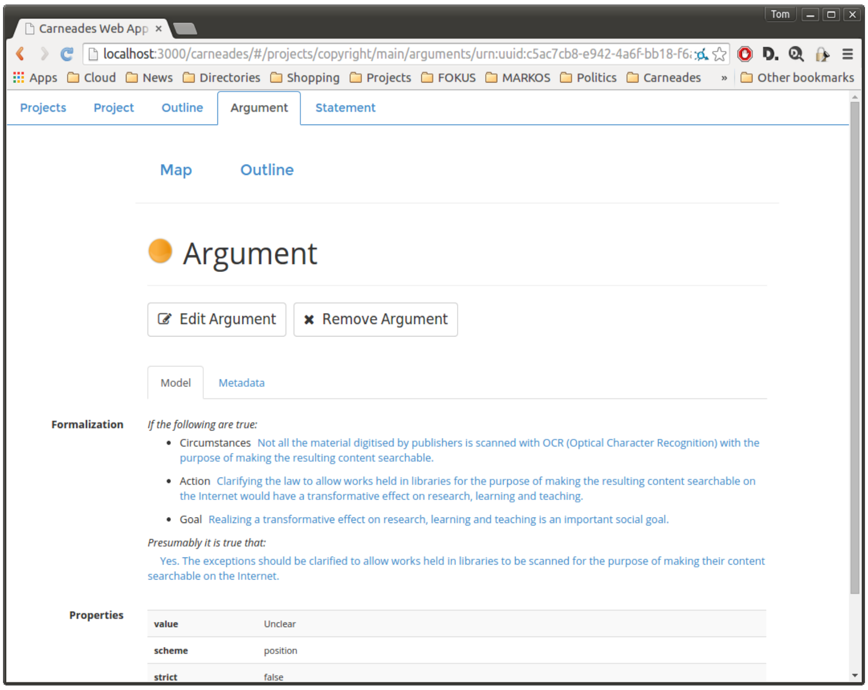

Fig. 6. Setting argument Properties in Carneades

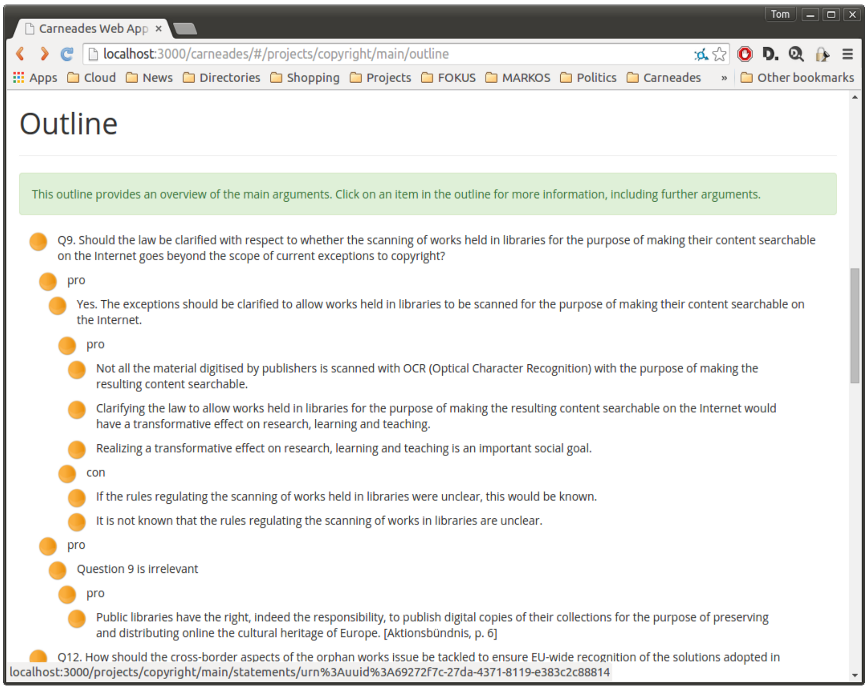

Fig. 7. Text visualization in Carneades

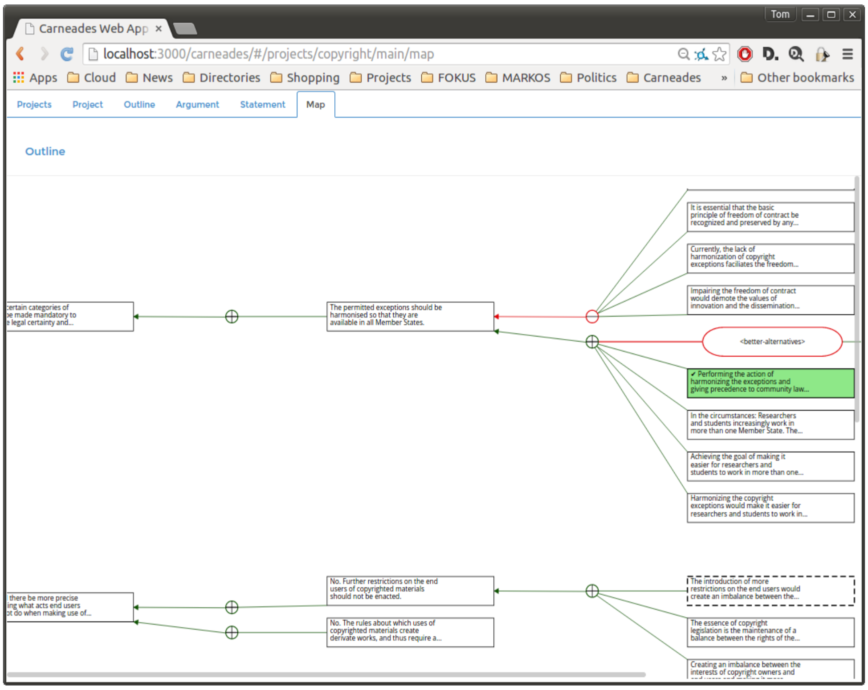

Fig. 8. Graph visualization in Carneades

Visualization plays an important role in the process of argumentative marking of the texts under study. The main purpose of implementing visualization in argument markup programs is to check the correctness of the markup and identify markup errors made by markers, i.e. real people. Visual representation of argumentation using software includes general-purpose text markup tools such as WebAnno [49] and INCEpTION [50]. WebAnno is a broad-spectrum, multi-user web-based tool for text annotation, including morphological, syntactic and semantic layers. Additionally, WebAnno can define custom layers, allowing it to be used for non-linguistic tasks such as argumentation representation. The INCEpTION tool was developed as an extension of WebAnno, focused on semantic markup. In addition to the capabilities of WebAnno, this tool allows you to connect recommendation systems to automate markup and import knowledge bases for tasks such as entity linking. INCEpTION allows you to export markup in a variety of formats, including XML and TSV.

Let's look at the representation of argumentation in the INCEpTION interface. As an example of argumentation, we take a fragment of the dialogue between Ivan Bezdomny and Woland from M. Bulgakov's novel "The Master and Margarita" (Fig. 9).

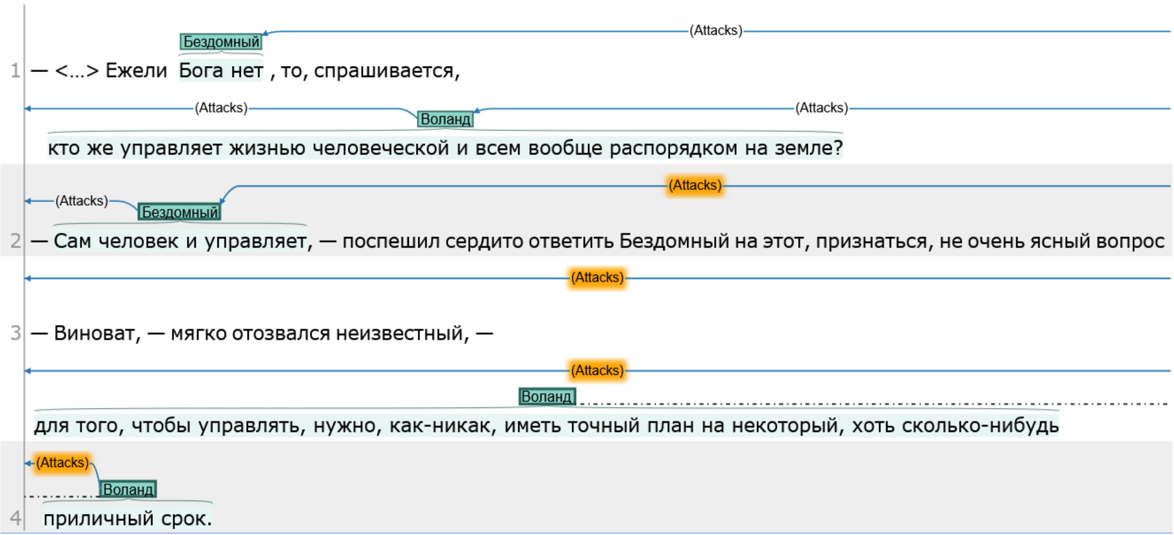

Fig. 9. Example of argumentation markup in INCEpTION

The dialogue is marked with an abstract argumentation framework [51], which consists of two sets of arguments corresponding to the participants in the dialogue, Woland and Bezdomny, and an attack relationship between the arguments. Sets of arguments are represented in the markup interface using the tags "Bezdomny" and "Woland", and the attack relation is represented by arrows "(Attacks)".

Recently, developments in the field of argumentation have been aimed at solving several problems associated with the use of IT technologies to automate processes in the research and analysis of argumentation.

One of the main trends is the development of mechanisms for automatic recognition of argumentation. Thus, a group of Russian scientists [52] developed a software package designed to support the study of argumentation in Russian-language popular science texts. At the same time, the problem of automatic recognition of arguments based on the use of linguistic indicators has been solved with the help of an ontology built on the basis of the AIF format (Argument Interchange Format) [53], and graph- oriented argumentation. The graph visualization implemented in the software package is an auxiliary tool and serves to study the adequacy of identifying argumentation. In another study aimed at building and testing a method for automatically identifying argumentation techniques in scientific texts, the authors use a software tool for marking up texts, and the graph visualization of argumentation markup implemented in it is intended for analysis and interpretation of the results obtained [54].

Conclusion

Analysis of the research literature, as well as the results of previous studies and our own experience in using the software, allow us to draw the following conclusions:

1) when studying the implementation of visual representation of argumentation in software, researchers do not always connect its features with the theoretical foundations underlying its functioning;

2) the implementation of visualization in software is based on formal theories that specify the choice of appropriate argumentation schemes;

3) when choosing software, researchers focus on the capabilities of the visualization implemented in it, which are determined by specific application tasks;

4) there is both highly specialized software (for example, designed for argumentative markup or visualization of public debates) and universal software that can be used to solve a wide range of problems.

During the study, we tried to test the capabilities of numerous software presented in the research literature through our own experience. However, not all solutions are currently available. Some programs are no longer supported, and their outdated versions cannot be used in modern operating systems. Some of the developed software is inaccessible due to the fact that the addresses of their developers' sites indicated in the literature do not exist, and searches on the Internet did not lead to their discovery. Moreover, as can be seen from the entire body of literature studied, the main intensive development and use of the overwhelming majority of argumentation visualization software dates back to the period from the early 2000s to 2013. Analysis of the current state of affairs in this area suggests that:

1) the development of software based on formal grounds has reached its apogee and the algorithmic approach to its creation has exhausted itself;

2) those few solutions that are still developed and supported are quite universal and allow them to be used to solve a wide range of problems related to the need for visual representation of argumentation, and, above all, for educational purposes to develop argumentation and critical thinking skills (for example, OVA, Carneades, Rationale);

3) applications and web-based systems designed for argumentative analysis of public debates and discussions within the framework of the development of electronic democracy do not lose their relevance;

4) visualization plays an important role in argumentative markup programs, in which it is necessary to identify the correctness of the markup, i.e. is a helper function.

The above conclusions can be used as basic recommendations when choosing software for solving applied problems in which a visual representation of argumentation is necessary.

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