An Experience in Documenting Medical Discussions through Natural Argumentation

Daniela Fogli, Massimiliano Giacomin, Fabio Stocco, Federica Vivenzi

Dipartimento di Ingegneria dell'Informazione
Università degli Studi di Brescia
Via Branze 38, 25123 Brescia, Italy
{fogli,giacomin}@ing.unibs.it
{fabio.stocco85,federica.vivenzi}@gmail.com

Abstract. The paper presents a prototypical tool to support the documentation of medical discussions. The development of this tool came after a long phase of requirement specification and prototyping activity, which allowed identifying two main functionalities for the tool, corresponding to two components. A first component is devoted to support the user in documenting clinical discussions, exploiting a graphical notation tailored to physicians' habits. A second component exploits argumentation schemes in order to analyze documented discussions, possibly bringing to light weaknesses in the reasoning process.

Keywords: clinical discussions, discussion representation, argumentation schemes.

1 Introduction

Medical activity often requires different specialists to participate in meetings, in order to discuss cases, diagnoses or methodologies to adopt. This may happen periodically, when the hospital structure hosts patients that must be assisted over long periods of time, as in the case we analyzed during our collaboration with the Department for Disabled People of an Italian hospital. Here, patients affected by a variety of physical and cognitive disabilities are hosted in a set of home units, where they are assisted in their daily activities and, in some cases, are supported through a rehabilitation process; patient disease or healing evolution are regularly discussed in physician meetings. But meetings among different medical specialists also take place in every hospital ward in case of difficult diagnoses, interesting cases or rare pathologies.

However, as witnessed by many physicians we have interviewed, these discussions are never documented, neither on paper nor in electronic documents: medical specialists analyze symptoms, propose hypotheses, read examination results and, through a progressive development of the discussion, arrive for example at suggesting to adopt some drug treatment or to acquire more data through a further examination; only the decisions taken at the end of the discussion are traced in paper or electronic patient records.

In this paper, we describe a prototypical tool we have designed in collaboration with representative users, which aims at supporting the documentation of medical discussions. The purpose of this tool is two-fold: 1) it should allow physicians to recall a previous discussion, having a structured view of the alternative hypotheses taken into consideration and of the reasons why they were accepted or discarded, in order to continue the discussion in the light of new information concerning for example new examination results or the evolution of a patient's clinical condition; 2) it should help physicians identify weaknesses in the reasoning process, e.g. discovering that an alternative diagnosis has not been taken into consideration, or that an available treatment has been neglected, or that a decision taken should be reconsidered in the light of a particular patient's condition.

Our goal is to provide a tool that allows documenting argumentation processes, without forcing users to know the abstract theory necessary to describe them. The idea is remaining as much as possible close to the considered domain, namely to its vocabulary and best practices, and thus making argumentation a natural process.

The paper is organized as follows. Section 2 outlines the proposed approach and compares it with related work in the field of Clinical Decision Support Systems and computer-supported argumentation visualization. Section 3 describes the component of the tool devoted to the discussion documentation, while Section 4 presents the component devoted to discussion analysis. Finally, some brief conclusions are drawn in Section 5.

2 Outline of the proposed approach and related work

Problems that teams of physicians often have to face can be regarded as ill-structured (or wicked) problems [1]. Among others, several characteristics of wicked problems are worth mentioning for the medical domain. Problem specification is often ambiguous and incomplete, every problem is essentially unique and there is not a predefined path that could be followed from the problem to the solution, but rather problem solution may require several iterations, according to a trial and error approach. Moreover, multiple information sources are necessary to acquire all the knowledge related to the problem; particularly, in the medical domain, knowledge is very huge, in continuous evolution, incomplete, uncertain, inconsistent, vague, and heterogeneous [2]. The search for a problem solution involves different stakeholders, with different culture and background; in the medical domain, collaboration among different specialists, with different competencies in a variety of fields, is often essential to arrive at a correct diagnosis.

Wicked problems are often dealt with the help of Decision Support Systems (DSSs) [3][4], which are interactive software systems that provide decision makers with all the information related to the case at hand, including suggestions for actions in response to events, and make it possible to explore available data from different points of view and through different visualization tools, as well as to simulate scenarios that may occur as a consequence of some decision. In the medical domain, a variety of Clinical Decision Support Systems (CDSSs) have been proposed. CDSSs are very complex systems that must facilitate the coordination of the activities of different specialists and help them manage a huge amount of information, coming from heterogeneous sources, such as clinical trials, guidelines, historical data, and best practices [5][6]. CDSSs include systems for the management of electronic medical records, such as WebPCR [7], LifeLines [8], and CareVis [9], which allow monitoring the state of patients under specific medical treatments. There are also systems that, beyond presenting information, provide also suggestions about the decisions to take [10]; whilst others, such as REACT [11] or HT-DSS [12], aim at helping physicians perform complex planning activities. Finally, there are also some CDSSs, such as CAPSULE [13], which provide justifications of suggestions.

However, the above CDSSs do not encompass adequate tools to track collaborative decision making processes; they provide classic communication methods, such as email or chat, which do not allow structuring the discussion, and which require that all exchanged messages are examined from the beginning, whenever decisions and motivations underlying them are to be recalled after a certain period of time.

In order to develop a tool to document clinical discussions, we have carried out a long phase of requirement specification and prototyping activity. The starting point was the analysis of a video taken from a meeting of a group of specialists discussing the case of an old patient affected by disorientation problems. The repeated examination of the video allowed identifying the discussion objectives, the kind of information that are exchanged, the structure and the elements of a discussion, as well as how a discussion is managed. Participants in the discussion usually propose some hypothesis, for example "Mr. T. might be affected by a cognitive degeneration", by sustaining it with information coming from direct observation (e.g., "Mr. T. does not find his room anymore"), from examinations, or from other information sources. In other words, some physicians provide their arguments to sustain a hypothesis, whilst the others usually propose counterarguments to attack that hypothesis, by basing their reasoning on further information sources or on a different interpretation of existing data (e.g., "Mr. T. could have a vision problem"). This "verbal and social activity of reasoning aimed at increasing (or decreasing) the acceptability of a controversial standpoint" [14] is what is usually known as *argumentation*.

Existing systems implementing argumentation mechanisms have been thus analyzed, in order to derive useful hints for the design of our tool for medical discussion documentation. Most studies concerning these systems are mainly focused on dialogue protocols and on algorithms ruling the behavior of software agents, rather than on the representation of the process human users carry out in collaborative decision making; indeed, in this case, a suitable representation of arguments must be studied, and language and interaction style of the system must be tailored to users' needs, preferences, and cultural background. To this purpose, we have focused on the field of computer-supported argumentation visualization. According to [14] and [15], computer-supported argumentation visualization systems must present arguments in a clear and simple way, by adopting a language close to natural language and offering users an intuitive and easy-to-use interface. These systems are usually designed for a specific application domain (e.g., education, law, politics) and provide different kinds of diagrammatic representations of arguments, based on graphic notations proposed in argumentation theory. An interesting overview of such systems is presented in [14]; among these systems, we have analyzed ArgVIS [14], Araucaria [16], Rationale [17], SEAS [18], Compendium [19], and Carneades [20].

In the context of the present paper, these systems can be classified along two dimensions, i.e. the purpose of argument visualization and the graphical language exploited for this task.

As far as the first dimension is concerned, argument visualization can be applied to two purposes at least. On the one hand, some tools focus on providing a structured representation of the arguments found in a textual document, with the aim of identifying and analyzing them. This is the case of Araucaria [16], whereby a user is able to select portions of text from a written document that can then be referred to in a diagrammatic representation of the arguments. On the other hand, some tools are more oriented on driving a discussion, allowing the participants to have a clear view of the arguments advanced so far and supporting them in the debate. For instance, both Compendium [19] and Carneades [20] provide the user with a set of *argumentation schemes* that can be exploited as patterns for the construction of new arguments as well as for the identification of the relevant counterarguments [21][22]. A similar view is enforced in ArgVIS [14], which also allows the users to interactively modify a debate graph with different privileges. The distinction pointed out above is called "argument as product" vs "argument as process" in [21].

As for the second dimension, a variety of diagrammatic languages are exploited to represent the arguments. For instance, Araucaria [16] supports Wigmore diagrams [23], Toulmin's notation [24] as well as a standard notation, while the languages adopted in Rationale [17], ArgVIS [14] and Compendium [19] are IBIS-like [25].

Since the early phases of the iterative development of the tool, some user requirements have been identified with respect to the characteristics above:

- Physicians are not willing to follow any discussion protocol, but they want to feel free to participate in the discussion according to their usual habits. For instance, sometimes they want to point out all of a patient's symptoms, other times they want to focus on a subset of them to identify a diagnosis, other times they tentatively reason about a diagnosis and look for the corresponding symptoms.
- Physicians adopt a specific medical terminology with a shared meaning, and do not accept to characterize propositions in abstract ways, e.g. identifying a major premise w.r.t. a minor one, or distinguishing between data and general rules.
- Even though physicians interact by pointing out arguments and counterarguments, they are not willing to make the relevant structure explicit during the discussion, let alone conform to a predefined scheme.
- Physicians require a structured representation of a previous discussion to somewhat adhere to the way discussion has been carried out. In particular, they do not accept to structure the information according to a predefined scheme if this does not reflect the order in which information has been pointed out. For instance, if a hypothetical diagnosis has been proposed before looking for symptoms, they do not accept a discussion representation where this order is reversed, e.g. presenting the symptoms first and then a diagnosis as a possible cause.
- Physicians require some information to be grouped according to specific needs, e.g. all clinical examinations and related results should be visualized together.
- The language used to document the clinical discussion must be clear, easy to understand and specific to the medical domain.

While the above requirements leave little space for *documenting* a clinical discussion by means of the graphic languages proposed in argumentation theory, we have experimented their adoption to *analyze* the discussion “a posteriori”. In particular, we have exposed physicians with a prototypical medical discussion represented in several notations and got their feedback. Wigmore diagrams [23] turn out to be difficult to understand, while Toulmin’s model [24] appears somewhat abstract, in particular evidencing the distinction between its components is considered unnecessary. On the other hand, physicians have recognized the usefulness of argumentation schemes [22] specifically devised for the clinical domain, similar to those exploited in Carrell+ [26]. Argumentation schemes turn out to be easily understandable, and physicians agree that they may be a valid instrument to identify weaknesses in the discussion, e.g. that a possible diagnosis has been neglected, that a doubt about an accepted diagnosis may be raised, that a clinical test should be prescribed, or that a possible treatment has not been taken into account.

On the basis of these considerations, the tool has been structured in two components.

A first component allows a trained user to document a clinical discussion by producing a graphical representation, possibly after its conclusion, on the basis of a video recording of the discussion or of paper-based notes. This choice is motivated by the fact that physicians often interact under critical time constraints, thus the use of the tool during the discussion may be regarded as time-consuming. In the iterative development of the first component, attention has been focused on the graphical language adopted to represent the discussion: on the one hand it must be tailored to the physicians’ habits in order to fulfill the requirements presented above; on the other hand, it must guarantee a structured representation of the discussion in order to allow physicians to quickly recall it after some time.

A second component is devoted to the analysis of a discussion previously documented by means of the first component. This second phase is optional, and is delegated to an expert user (possibly the same as the user of the first component) familiar with argumentation schemes, which is allowed to select argumentation schemes from a repository and to instantiate them with the elements of the discussion (this somewhat resembles the use of Araucaria [16]).

3 Creating Arguments in Medical Discussions

3.1 Documenting Medical Discussions

The part of the tool to be used for tracking and managing medical discussions has been developed through an iterative approach, including the design of paper-based and interactive prototypes and various interviews with representative users (students in medicine and physicians). This activity has led to define the terminology to be used in the system and to understand how to support the creation and modification of a discussion.

The idea is structuring each discussion about a clinical case as a tree diagram, somewhat resembling the IBIS-like notation of Rationale [17], but adopting a specific medical ontology. More specifically, the tree diagram will include different kinds of nodes corresponding to the different medical concepts that physicians use during discussions (diagnosis, symptom, examination result, and so on). Therefore, users are not forced to use terms not familiar to them, such as "argument", "counterargument", "support", "attack", even though they will implicitly express such kinds of concepts and relations during tree construction.

Figure 1 shows a screenshot of the resulting system. This first version of the system is in Italian to increase its acceptance by our users, but it will be described in the following by using English terms. The top bar includes the buttons for creating a new discussion, opening a previous discussion, saving the current discussion, and analyzing the discussion by activating the other component of the system. The main area is composed of three parts:

1. A *left area*, which includes the 5 types of nodes – diagnosis, non-pathological hypothesis, motivation pro, motivation against, and examination request – that represent the basic element types of a discussion. The distinction among these element types is subtle and different physicians can classify an information item in different ways. On the other hand, the 5 types of nodes arose during requirement analysis as those physicians want to be available in the system. Each of the five nodes can be included in a discussion by dragging-and-dropping it in the central area (see below); node instantiation is carried out by the system by asking the user any useful content.
2. A *central area*, which is in turn divided in 7 tabs: Discussion, Personal Data, Symptoms, Semiotics, Case History, Direct Observation, and Examination Report. The "Discussion" tab will host the tree representing the discussion: the root node (Clinical Case) is generated automatically by the system when the user creates a new discussion; whilst, the other nodes are created by dragging and dropping the elements available in the left and right areas. It has to be remarked that the links between nodes in the discussion tree do not have a precise meaning; they simply reflect the fact that a consideration in a discussion is referred to a previous one in some way. Therefore, users can never build an inconsistent or syntactically incorrect diagram. Information items can be organized according to well-founded structures in the analysis component (see Section 4). The remaining tabs correspond to the six different sources of information that can be used to support or attack the elements of the discussion. Indeed, information are usually gathered from the interviews with patient and patient's relatives (personal data, symptoms, and case history), from the detection of clinical signs by the physician during a physical examination (semiotics), from observations of patient behavior by physicians, nurses, social assistants, and other stakeholders (direct observation), and from results of clinical examinations (examination report). The tab order reflects the order followed by the physician to gather information before proposing a diagnosis or a non-pathological hypothesis.
3. A *right area*, which summarizes all the information gathered during the meeting, and whose details can be found in the tabs in the central area: each item can be selected and included in the "Discussion" tab to become an element in favor or against another element of the discussion, which is usually a diagnosis or a non-pathological hypothesis.

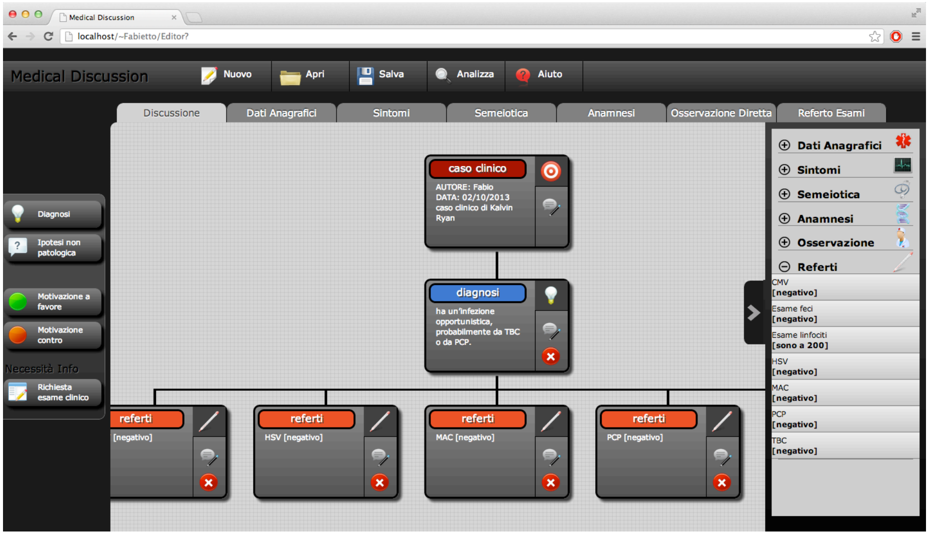

Fig. 1. The part of the tool devoted to the documentation of medical discussions

In Figure 1, the "Discussion" tab shows a discussion tree under creation, referring to a case from the well-known "House (M. D.)" TV series. House's team is talking about the problems of Kalvin Ryan, a young patient affected by HIV. Dr. House has suggested that the patient has an opportunistic infection, thus a diagnosis has been added under the tree root. Dr. Coleman has objected that the results of clinical examinations exclude this diagnosis; therefore, four nodes against the infection diagnosis have been dragged and dropped under the diagnosis node. These nodes have been created by selecting elements from the results of examination reports summarized in the right area.

3.2 Evaluation with users

An expert physician, a novice physician and a senior student in medicine have participated in testing the current version of the prototype. After a brief training that illustrated how the system can be used to document the House's discussion described in the previous section, users have been required to document the subsequent part of the same discussion. A thinking-aloud observation method has been adopted to collect as much as possible information from users, namely users' reasoning strategies, terminology, and reactions to the system appearance and behavior.

The first part of the test consisted in a series of specific tasks extracted from the House's case, which allowed users to familiarize with the system and evaluators to identify its main usability problems. In the second part of the test, users have been required to autonomously create a discussion model; this has been useful to investigate if ambiguities and imprecisions affect the system from the point of view of the logical development of a discussion. In particular, we have observed that the two more experienced users (expert and novice physicians) had much less difficulties in performing the task with respect to the student. They moved easily among tabs and lateral areas for creating the various nodes, even though they tended to work out again the discussion content according to their experience and background.

It is interesting to note that when symptoms are described in the discussion, they are correctly added in the corresponding tab and then used as elements to substantiate some diagnosis or non-pathological hypothesis; whilst, when the absence of some symptoms is specifically mentioned in the discussion, this information is used in "motivation against" nodes. Even though this is perfectly coherent with the discussion logic, the expert physician raised some perplexities about this asymmetrical behavior; therefore, we plan to examine this situation in the future, possibly proposing a re-classification of concepts.

Notwithstanding the physicians operated freely on the discussion, the resulting diagrams presented some interesting regularities. For example, nodes at level 1 refer always to diagnoses or non-pathological hypotheses, and actual chains of reasoning are created after these nodes. The tree representation shows its effectiveness when a diagnosis is progressively refined through more specific diagnoses, as a consequence of the consideration of additional information. For instance, Figure 2 presents an excerpt of the discussion model created by the novice physician, where three diagnosis nodes are nested from top-left to bottom-right and a forth node in the chain includes the request of a further examination whose results could substantiate the last and most probable diagnosis.

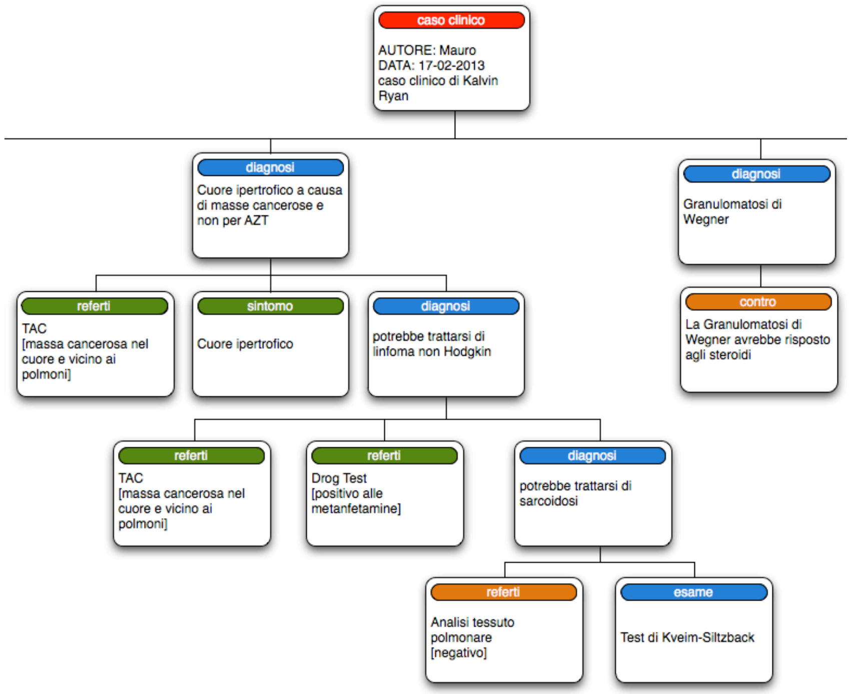

Fig. 2. Excerpt of a medical discussion described by a physician using the tool

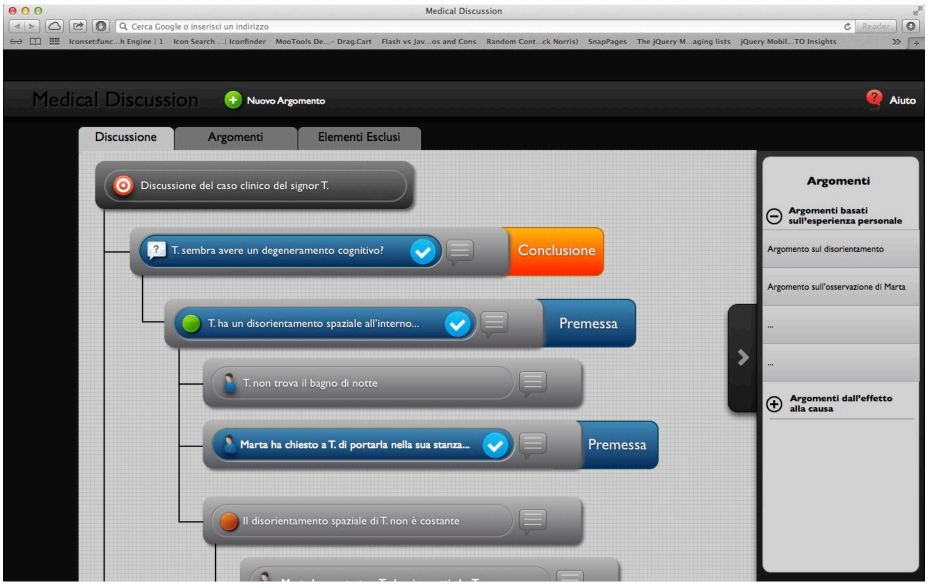

Fig. 3. The part of the tool devoted to the analysis of medical discussions

In a final brief interview, users have confirmed that the tool could be very useful for documenting medical discussions. According to the users, the system may facilitate the comprehension of a discussion and of the decisions taken, thanks to the schematic and structured model that the system allows one to create. Users also added that the system could help physicians arrive at more robust diagnoses in less time. Finally, users said they found the system easy to use and to learn, by clarifying that the graphical representation of the discussion stimulates the participation in the modeling activity.

4 Analysis of Discussions Based on Argumentation Schemes

The component devoted to the analysis of a discussion exploits a different and more synthetic visualization of the discussion, based on a multi-level list and no more on a tree diagram. In this way, more space is reserved to the content of the discussion and navigation can be limited to a vertical scroll. Figure 3 shows a screenshot of this part of the system. The main area is composed of three tabs, called Discussion, Arguments, and Excluded Items. When the user accesses the first tab s/he can walk through all the elements of the discussion and access their details. Here the user can add an argument by selecting the button “New Argument” on top of the screen. This selection activates a popup window that asks the user the argument title and to choose, from an available list, the argumentation scheme s/he would like to use for the argument under creation. After this selection, the user can identify with a simple click on the list items those elements that can be regarded as the argument premises or conclusion. In particular, on the basis of the analysis of the recorded video and inspired by the work of Walton [22], we have defined five argumentation schemes suitable to the medical domain. However, these schemes represent only a preliminary proposal, which deserves further investigations in the future. All the arguments created by the user with reference to a discussion are summarized in the right area of the screen; here, arguments are classified on the basis of the argumentation schemes of which they are instances. Furthermore, each argument selection in the right area makes related premises and conclusion appear in the multi-level list.

The "Arguments" tab (Figure 4) shows the details of the arguments identified in the discussion: the left part presents the list of the arguments, classified again according to the argumentation schemes; the right part provides the details of a selected argument, namely its Premises, Conclusion, and Critical Questions.

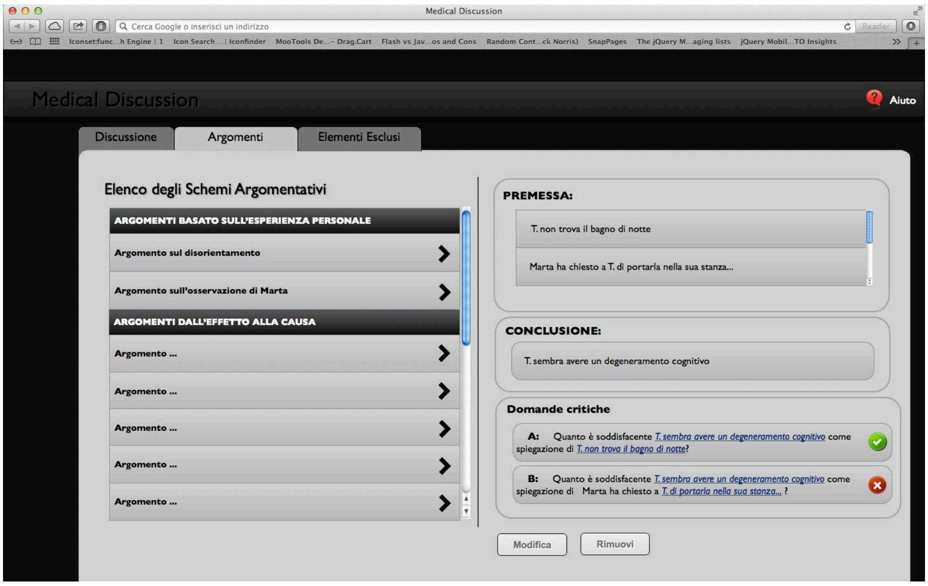

Fig. 4. The tab of the main area showing argument details

Let us note that the critical questions are those associated to the argumentation scheme chosen by the user during argument creation; critical questions are properly instantiated by using data in argument premises and conclusion. For each critical question, the user can indicate if an answer to the question already exists (green checkmark), or if the answer is still missing (red cross sign).

The last tab ("Excluded Items") gathers all discussion elements that do not belong to any arguments. In this way, the user is provided with further information that s/he might consider for deciding about the answer to critical questions.

The part of the system devoted to the analysis of discussions has not been tested with users yet. We hypothesize that a team member, trained in basic notions of argumentation theory and argumentation schemes, could use it after a discussion has been documented. In this way, this expert could help the other members of the team identify weaknesses in the discussion, and suggest further investigations where answers to critical questions are missing.

5 Conclusions

The tool presented in this paper can be regarded as a proof-of-concept: it has been very useful to validate with users our idea of creating an argumentation-based system to support discussion documentation and analysis in the medical domain. The iterative and participatory design of this tool has allowed us to understand physicians' reasoning process and terminology; this way, the tool is able to foster argumentation in a natural way, being it tailored to the application domain. The key feature that distinguishes our approach with respect to previous proposals, such as Carrell+ [26] and HERMES [27], is the organization in two modules devoted to the documentation and the analysis of clinical discussions, respectively. Since well-founded structures can be exploited in the analysis phase, the first module allows the user to represent the discussion without adhering to a set of structural constraints, thus speeding up the documentation phase. On the other hand, the graphical representation allows physicians to quickly recall and continue a previous discussion. We believe that finding a good trade-off between a structured representation and a natural interaction is essential to motivate the use of the prototype, given the critical time constraints often characterizing the job of medical personnel. This has been confirmed by the evaluation with users of the part of the system devoted to the representation of medical discussions. Participants in the evaluation judged the system as very useful and coherent with their mental model of discussions; furthermore, they said that it allows deepening the reasons under decisions, thus improving comprehension of the different points of view.

The part of the system devoted to the analysis of a discussion based on argumentation schemes has not been tested with real users yet. Therefore, future work will be mainly focused on the test and revision of the features that help the user identify arguments and answer to critical questions. Attention will also be paid to summarizing the parts of the graphical representation the user is not focused in, possibly exploiting the techniques presented in [28].

References

1. Rittel, H., Webber, M.: Dilemmas in a General Theory of Planning. Policy Sciences, Vol. 4, Elsevier Scientific Publishing Company, Inc., Amsterdam, pp. 155–169 (1973)
2. Cortés, U., Vàzquez-Salceda, J., Lòpez-Navidad, A., Caballero, F.: UCTx: A Multi-Agent System to Assist a Transplant Coordination Unit. Journal of Applied Intelligence 20(1), 59-70 (2004)
3. Burstein, F., Widmeyer, G. R.: Decision support in an uncertain and complex world. Decision Support Systems 43, 1647-1649 (2007)
4. French, S., Turoff, M.: Decision Support Systems, Communications of the ACM 50(3), 39–40 (2007)
5. Wyatt, J. C., Sullivan, F.: ABC of health informatics: How decision support tools help define clinical problems. British Med Journal 331(7520), 831-833 (2005)
6. Fogli, D., Guida, G.: Knowledge-Centered Design of Decision Support Systems for Emergency Management. Decision Support Systems 55, 336-347 (2013)
7. Web Browser based Patient Care Report. http://emsfiresoftware.com/products/wpcr/

8. Plaisant, C., Mushlin, R., Snyder, A., Li, J., Heller, D., Shneiderman, B.: LifeLines: Using Visualization to Enhance Navigation and Analysis of Patient Records. In: Proc. American Medical Informatic Association Annual Fall Symposium, Orlando, USA, pp. 76-80 (1998)
9. Aigner, W., Miksch, S.: CareVis: Integrated Visualization of Computerized Protocols and Temporal Patient Data. Artificial Intelligence in Medicine 37(3), 203-218 (2006)
10. Peleg, M., Wang, D., Fodor, A., Keren, S., Karnieli, E.: Adaptation of Practice Guidelines for Clinical Decision Support: A Case Study of Diabetic Foot Care. In: Proc. Biennal European Conference on Artificial Intelligence (ECAI), Riva del Garda, Italy (2006)
11. Glasspool, D. W, Oettinger, A., Smith-Spark, J. H., Castillo, F. D., Monaghan, V. E. L., Fox, J.: Supporting Medical Planning by Mitigating Cognitive Load. Methods in Information in Medicine 46(6), 636-640 (2007)
12. Fogli, D., Guida, G.: Enabling Collaboration in Emergency Management through a Knowledge-Based Decision Support System. In: A. Respicio, F. Burstein (eds.), Fusing Decision Support Systems into the Fabric of the Context, IOS Press, pp. 291—302 (2012)
13. Walton, R.T., Gierl, C., Yudkin, P., Mistry, H., Vessey, M.P., Fox, J.: Evaluation of computer support for prescribing (CAPSULE) using simulated cases. British Medical Journal 315, 791-795 (1997)
14. Karamanou, A., Loutas, N., Tarabanis, K. A.: ArgVis: Structuring Political Deliberations Using Innovative Visualization Technologies. In: Tambouris, E., Macintosh, A., de Bruijn, H. (Eds.), Proc. of Electronic Participation, Third IFIP WG 8.5 Int. Conf. ePart 2001, Delft, The Netherlands, LNCS 6847, pp. 87-98, Springer (2011)
15. Buckingham Schum, S.: The Roots of Computer Supported Argumentation Visualization. In: Visualizing argumentation. Springer-Verlag, London, UK, 3-24 (2003)
16. Reed, C. A., Rowe, G. W. A.: Araucaria: Software for Argument Analysis, Diagramming and Representation. International Journal of AI Tools 13 (4), 961-980 (2004)
17. Sbarski, P., van Gelder, T., Marriott, K., Prager, D., Bulka, A.: Visualizing Argument Structure. In: G. Bebis et. al. (Eds): ISCV 2008, Part I, LNCS 5358, pp. 129-138 (2008)
18. Lowrance, J., Harrison, I., Rodriguez, A., Yeh, E., Boyce, T., Murdock, J., Thomere, J., Murray, K.: Template-Based Structured Argumentation. In: Okada, A., Buckingham Shum, S., Sherborne, T. (Eds.), Knowledge Cartography: Advanced Information and Knowledge Processing, Springer, pp. 307-333 (2008)
19. Compendium web site. http://compendium.open.ac.uk/index.html
20. Gordon, T. F.: An Overview of the Carneades Argumentation Support System. In: Reed, C., Tindale, C. W. (Eds.), Dialectis, Dialogue and Argumentation: an Examination of Douglas Walton's Theories of Reasoning, pp. 145-156 (2010).
21. Reed, C. A., Walton, D.: Argumentation Schemes in Argument-as-Process and Argument-as-Product. In: Proc. Conference Celebrating Informal Logic @25, Windsor, Ontario (2003)
22. Walton, D.: Argumentation Schemes for Presumptive Reasoning. Lawrence Erlbaum Associates (2006)
23. Wigmore, J.H.: The Principles of Judical Proof. Little, Brown & Co. (1913)
24. Toulmin, S.E.: The Uses of Argument. Cambridge University Press (2003)
25. Werner, K., Rittel, H.: Issues as Elements of Information Systems. Working paper No. 131, Heidelberg, Germany, July 1970 (Reprinted May 1979)
26. Tolchinsky, P., Cortés, U., Modgil, S., Caballero, F., Lòpez-Navidad, A.: Increasing Human-Organ Transplant Availability: Argumentation-Based Agent Deliberation. IEEE Intelligent Systems 21(6), 30-37 (2006)
27. Karacapilidis, N., Papadias, D.: Computer supported argumentation and collaborative decision making: the HERMES system. Information systems 26, 259-277 (2001)
28. Baroni, P., Boella, G., Cerutti, F., Giacomin, M., van der Torre, L., Villata, S.: On Input/Output Argumentation Frameworks. In: Computational Models of Argument, Proc. of COMMA 2012, Vienna, Austria, pp. 358-365 (2012)