Towards a Medically and Legally Sufficient Documented Argumentation Model for Medical Information Retrieval Systems

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Abstract

Medical decision-making in Germany is governed by statutory requirements defined in the German Social Code, German Civil Code, and German Criminal Code. Deviations from the accepted medical practice or unforeseen complications frequently trigger legal investigations regarding medical malpractice, yet medical Information Retrieval Systems offer little support for documenting the underlying medical reasoning and argumentation in a structured and legally sufficient way. As a result, essential argumentative elements are often remaining implicit or as unstructured text records that must be extracted manually with high effort, contributing to findings of malpractice in roughly $25-30\%$ of expert surveyor reports. In this paper, we investigate how medical individual case argumentation can be formalized and embedded to meet medical and legal sufficient documentation standards. Hence, we look into the medical and legal requirements from law, practice, guidelines and verdicts to design a formal medical individual case argumentation model based on the Resource Description Framework and Argument Interchange Format. Additionally, we design a prototype system implementation strategy supporting graph-based documentation and visualization of medical argumentation as well as serialization into natural-language text for legal argumentation. We outline an evaluation strategy through a user study and present a concrete action plan for a Cognitive Walkthrough. Furthermore, we provide mockups of the system and a representation of an example medical letter to demonstrate the feasibility of our approach. We also identify areas for future work to improve the system and the model. Our contribution is a review of the medical and legal documentation requirements, a formal model to represent medical individual case argumentation, and an implementation plus evaluation strategy facilitating the model, providing a foundation for future research and evaluation.

Keywords

Medical Argumentation, Resource Description Framework, Argument Interchange Format, Medical Documentation

1. Introduction and Motivation

In Germany, medical experts operate within a dense web of regulations and legal standards. Diagnoses, therapies and their documentation are primarily codified and governed by the German Social Code Book Five (SGB V, German: *Sozialgesetzbuch Fünftes Buch*), the German Civil Code (BGB, German: *Bürgerliches Gesetzbuch*), and the German Criminal Code (StGB, German: *Strafgesetzbuch*) [1, 2]. Deviations from the accepted medical practice (German: *Standard*) can constitute medical malpractice (German: *Behandlungsfehler*), potentially leading to legal disputes [2]. Obligations, such as those in §630f BGB [3, §630f], require medical experts to keep documentation records, but say nothing about what constitutes as a sufficient documentation record. Other legislation, such as SGB V §106d [4, §106d], BGB §§280(1) [5, §§280(1)], §630h [3, §630h], StGB §§223 et seq. [6, §§223 et seq.], and homicide under §§211 et seq. [7, §§211 et seq.], expose medical experts to a variety of legal risks, ranging from refusals of reimbursement by statutory health insurers or private patients to claims for damages and even criminal prosecution when documentation is missing, incomplete or wrong.

The evidence-based medicine aims to support medical experts in their decision-making processes by

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providing the current accepted medical practice [8], but should also include the medical experience of medical experts [9]. Scientific knowledge in the medical domain is huge and growing rapidly, which requires medical information retrieval systems to support medical experts in finding relevant information [10]. The Information Extraction Lifecycle (IELC) [11] offers a structured approach to the various activities involved in information extraction, including data collection & preparation, extraction & enrichment, information & knowledge organization, and information access & retrieval, but it does not cover legal frameworks.

Current medical information retrieval systems offer virtually no support for medical experts in documenting or structuring the premises, inferences, conclusions, and, in general, the argumentation of a medical individual case, in a medically and legally sufficient manner. Medical experts must manually reconstruct their argument and reasoning from existing documentation, such as narrative notes, medical reports, and laboratory results. Medical surveyor reports (German: *Medizinische Sachverständigengutachten*) found $25\% - 30\%$ of investigated individual cases are subject to medical malpractice, e. g., due to insufficient or inadequate documentation of the medical decisions and the underlying arguments, faulty behavior, or deviations from the accepted medical practice [12]. Statutory health insurance companies requested $12\,304$ medical surveyor reports (3731 findings of malpractice) in 2024 from the Community of Medical Services (German: *Gemeinschaft der Medizinischen Dienste*) [13] as well as 7607 requests (1134 findings) to the Expert Commission and Arbitration Board of the German Medical Association (German: *Gutachterkommision und Schlichtungsstelle der Bundesärztekammer*) [12].

A key open gap in prior research is the formalization and implementation of documentation standards that meet legal requirements. There is no widely accepted medical individual case argumentation model, no possibility to capture uncertainties in medical arguments, and no mapping of documented medical facts to accepted legal argumentation schemes, like the principle of subsumption. This work aims to close those gaps, leading to the research question RQ: How can medically and legally sufficient documented argumentation of an individual case be formalized and embedded into a medical information retrieval system?

Hence, we introduce a medical individual case argumentation model as a formal structure that represents diagnoses, therapies, and their relations as medical arguments in a machine-readable graph structure as well as offer built-in serialization of the graph into natural-language legal argumentation. Following the four-phase (observation, theory building, system development, experimentation) methodology of Nunamaker et al. [14] and adopting User-Centered System Design principles from Norman and Draper [15], we design, prototypically implement, and evaluate a medical individual case argumentation information retrieval system and derive the following research objectives for this paper: ($RO1$ - Observation) review existing medical and legal documentation requirements regarding argumentation and existing technologies that allow for medical argumentation to ensure medically and legally sufficient documentation; ($RO2$ - Theory Building) design the formal medical individual case argumentation model that aligns with those requirements; ($RO3$ - System Development) develop an implementation strategy for a prototype of a medical information retrieval system based on the designed medical individual case argumentation model; ($RO4$ - Experimentation) create an evaluation strategy and conduct a preliminary evaluation of the prototype and medical individual case argumentation model based on system mockups. By doing so, we contribute to the medical field by identifying the requirements for medically and legally sufficient documentation and a clear strategy for implementing them.

2. Related Work & Medical and Legal Argumentation Requirements

This section deals with $RO1$ and provides an overview of existing research and technologies related to legal and medical argumentation documentation requirements. Various software tools for medical information retrieval already exist. Direito et al. [16] showcase a system that allows documenting medical records, but rely on manual documentation. Prior work of Delussu et al. [17] survey electronic health systems storing patient data that lack automated argumentation.

Standards for the exchange of medical documents, such as the Consolidated Clinical Document Architecture [18], exist and are widely adopted. However, these standards also focus on exchanging existing documentation rather than generating legally sufficient documentation. Many tools for information extraction in the medical domain that conform to these standards exist [19]. However, these approaches largely focus on extracting information, on producing legally sufficient documentation in isolation, or apply to different jurisdictions. To the best of our knowledge, no existing software applicable to the European Union or Germany integrates the information extraction lifecycle with mechanisms that support health professionals in creating medical documentation, ensuring legally sufficient documentation. In this work, we focus on the German jurisdiction and review the medical and legal requirements for medical documentation. Each identified requirement is labelled as a legal requirement (LR) or medical requirement (MR) and numbered for later reference.

The formal requirements for medical documentation are regulated by laws [1, 2, 3], but the amount of needed documentation to convince a judge to dismiss the accusation of medical malpractice is not specified clearly. Legal discussions often rely on court-appointed medical surveyor reports that investigate the whole treatment process, its formal documentation and evaluate whether the medical decisions were in accordance with the accepted medical practice [20]. The German Federal Court of Justice (German: *Bundesgerichtshof - BGH*) confirms in its verdict of 23 November 1982 - VI ZR 222/79, BGHZ 85, 327 [21] the importance of medical documentation as part of a meticulous treatment and contractual secondary obligation (German: *vertragliche Nebenpflicht*) that allows other medical experts to continue a treatment. The German Medical Association (German: *Bundesärztekammer*) also added the documentation obligation (German: *Dokumentationspflicht*) in §10 of their Model Professional Code for Physicians (German: *Musterberufsordnung - MBO-Ä*) [22] which is the basis for legally binding Professional Code of Conduct for Physicians (German: *Berufsordnung*). Medical experts are obliged to document all essential treatment procedures and measures, in particular the medical history, diagnoses, findings, therapies and their effects, as well as the proof of consent and verbal explanations of the patient separately ($LR1$), which is clearly defined in §630f BGB [3]. If this documentation should be used in legal proceedings, it must be submitted in German language ($LR2$) [23]. Patients consent and prior verbal explanation are a crucial part of the documentation of medical decision-making processes, because patients, not medical experts, finally decide and consent (German: *Einwilligung*) on all medical treatment procedures, regulated in §630d BGB [3]. Even though medical experts can expect that patients trust their expertise and medical decisions, they are obliged to inform patients about the medical treatment procedures, their risks and alternatives [24], especially when the risks of alternative treatments are substantially different from the risks of the proposed treatment ($LR3$) [25]. It is noticeable that the legal requirements for medical documentation obligations are rather defined by formal requirements to document facts and results regarding medical history (anamnesis), diagnosis, and decisions as separate argumentation parts instead of substantive requirements regarding the content of argumentation or its reasoning. Substantive requirements in §630a BGB [3] govern medical treatment, but not its documentation, by reference to the accepted medical practices ($LR4$) [26] of an experienced medical specialist (German: *Facharzt*) [27]. Hence, a medical malpractice is derived as the negligent failure to meet the accepted medical practices, even though there are exceptions when other medical practices promise more likely success for an individual case ($LR5$) [26]. The current accepted medical practice for medical decision-making processes to find a suitable choice of therapy starts with the anamnesis to gather information about the patients medical history [28], followed by the diagnosis to identify medical conditions [29] and finally the patients decision for a suitable therapy that can differ from the accepted medical practice ($LR6$).

Evidence-based medicine (EBM) is a common approach to determine the current accepted medical practice based on the best available evidence from scientific research, the experience of medical experts and the patients preferences [20, 9], whereas scientific evidence can be grouped into different levels of quality ($LR7$) [30], e. g. from medical expert opinions up to meta-analyses from multiple Randomized Controlled Trials (RCTs). Every patient and every medical case is unique and requires an individual case argumentation to find the best possible treatment for the patient, which is based on the current accepted medical practice and the specific circumstances of the case [10] and RCTs with their generalized scope

on specific topics do not necessarily apply to the current patient [30].

Arguments consist of a set of premises, a conclusion and an inference from the premises to the conclusion [31]. They can support or attack other arguments and can be represented as graph structures [31]. Legal argumentation in German courts follows the principle of subsumption (German: *Subsumtion*) where a specific case is subsumed under a general legal norm if the conditions of the norm are met [32]. It consists of the four elements: 1) main clause (German: *Obersatz*), 2) definition (German: *Definition*), 3) subsumtion and 4) conclusion (German: *Ergebnis*).

The medical counterpart of the subsumtion is the diagnosis where a specific medical case is subsumed under a general medical condition if the symptoms and findings of the case match the criteria of the condition [32]. In medical practice, an anamnesis and examination of medical condition characteristics are done before a diagnosis can be made, which is then followed by the decision for a suitable therapy. This medical approach is similar to the legal requirement $LR1$ of separate documentation of individual treatment steps and requires inductive reasoning to be representable in medical argumentation ($MR1$) [33]. Additionally, the conditional dependency between symptoms, examination findings, diagnoses, and therapies, the exclusion of diagnoses or therapies, as well as their causal relations must be representable in medical argumentation ($MR2$) [33]. Medical decision-making also includes working with uncertanties and incomplete information, which leads to the usage of clinical guidelines [34] with different types of quality that must be distinguishable ($MR3$) [33]. Similar to the legal requirement $LR7$, the quality of medical studies ($MR4$) must be be captured to enable reasoning regarding quantitative results as well as unsuccessful searches for evidence ($MR5$), e. g. unfitting studies or no found studies at all [10]. Another important aspect following $MR4$ and $MR5$, especially in EBM, is the need to document and cite the evidence ($MR6$) for all knowledge used in an argumentation. The Resource Description Framework (RDF) and Argument Interchange Format (AIF) are used to describe resources, arguments and their relations in a graph-based and machine-readable format [35]. They can be used to represent medical and legal arguments in a structured way to document decisions.

3. Medical Individual Case Argumentation Model and System Design

This chapter deals with $RO2$ and describes the design of a medical individual case argumentation model facilitating RDF and AIF as well as a user-centered [15] medical information retrieval system operationalizing it. Based on the legal and medical requirements regarding the documentation of argumentation identified in chapter 2, we derive a set of classes and properties plus introduce a formal model structure as well as outline an implementation strategy for such system.

The model itself should consist of a set of Resource Description Framework Schema (RDFS) classes that define RDF nodes for representing the argumentation and integrate them into AIF to model the arguments and their relations in a graph-based format. Table 1 provides an overview of the previously identified medical and legal requirements and relates them to respective model nodes. The model can represent the argumentation structure of the medical decision-making process, which includes the anamnesis, diagnosis and therapy decisions as separate argumentation parts. Medical and legal argumentation have to work with uncertainties and probabilities, so the model supports their representation in dedicated nodes *Confidence* and *Study Quality* as properties *studyLevelPercent*, *individualCaseLevelPercent*, and *qualityLevel*.

The system, on the other hand, is described from a user point of view by a use-case diagram in Figure 1 and shows the separate review and maintenance actions to allow medical experts as well as other relevant personas to interact with the model to create annotations, arguments and an argumentation. It supports the visualization of the model as graph as well as the serialization of the graph to a natural-language text format by the principle of subsumtion, which is the common format for legal argumentation in German courts as well as medical surveyor reports.

Requirement	Description	Model Class or Property
$LR1$	Separate documentation for at least anamnesis, diagnosis and therapy.	Finding, Symptom, Diagnosis, Therapy, Diagnostic Measure
$LR2$	The argumentation must be representable in German.	-
$LR3$	Document alternative therapies and their risks or benefits.	Alternative Therapy
$LR4$	Current accepted medical practices must be identifiable.	Knowledge, note, details
$LR5$	Treatment decisions that deviate from accepted medical practices must be justifiable.	Medical Expertise
$LR6$	Treatment decisions that deviate from accepted medical practices by patient request must be documented.	Patients Decision
$LR7$	Document the quality of a RCT.	Study Quality (qualityLevel), Confidence (studyLevelPercent, individualCaseLevelPercent)
$MR1$	Separate documentation of symptoms, examination findings, diagnoses, and therapies related by inductive reasoning.	Finding, Symptom, Diagnosis, Therapy, Diagnostic Measure
$MR2$	Document the conditional dependency, exclusion and causal relation of diagnoses and therapies.	Causal Argument, Symptom argues for, Symptom argues against (Differential Diagnosis)
$MR3$	Document the type of quality of clinical guidelines.	Knowledge, Confidence
$MR4$	Document the quality of (quantitative) RCTs.	Knowledge, Study Quality
$MR5$	Document unsuccessful search for scientific evidence.	Unknown
$MR6$	References to cited sources of evidence or knowledge.	Knowledge, note, details

Table 1
Overview of Medical and Legal Requirements

4. Implementation and Evaluation Strategy

In this chapter, we outline the implementation strategy for a prototype of a medical information retrieval system based on the designed medical individual case argumentation model ($RO3$) and present an evaluation strategy to assess the systems usability and usefulness through a user study with medical and legal experts ($RO4$). Therefore, we describe the required system components and provide the evaluation strategy for assessing the systems effectiveness. The implementation requires instantiations of four central key components as stated in Table 2: An orchestrator, the data model, a graph visualizer and a natural-language text serialization component.

Orchestrator	Coordinates interactions among components and packages, serving as the main entry point and managing the overall workflow for creating, visualizing, and serializing arguments.
Model	Argumentation maintenance, RDFS class node definitions and instantiations, RDF and AIF importer and exporter.
Visualizer	Display, order and view the model graph.
Serializer	Traverse the model graph and generate natural-language.

Table 2
System Component Overview.

The user interacts with the orchestrator *Orchestrator*, that delegates tasks to the other components. The model component *Model* takes care of creating and maintaining an argumentation in machine-

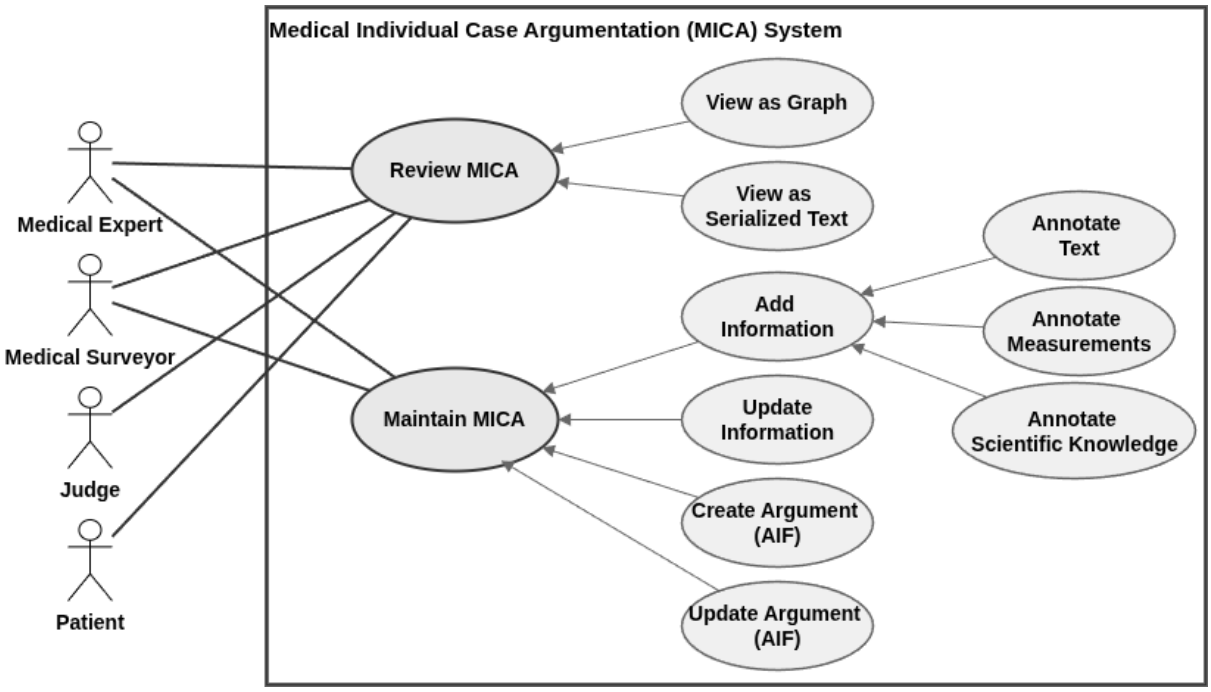

Figure 1: Use-case Diagram for the System.

readable formats of RDF and AIF. A central component for usability is the graph *Visualizer* component which orders and displays the arguments logically based on the medical and legal requirements from anamnesis to diagnosis to therapy from left to right. On top of that, the serialization component *Serializer* traverses the graph from right (therapy) to left (diagnosis, anamnesis) to derive the main clause, definition, subsumption and conclusion of the juristical subsumption and transforms the arguments into a natural-language text format.

We will assess the effectiveness of the system by representing medical records, e. g. medical letters, using the model as well as a planned user study with medical and legal experts, where we will evaluate the usability and usefulness of the system in supporting medical documentation and argumentation. Hence, Figure 2 and Figure 3 show an mockup representation of the Thieme Medical Letter, which is described more detailed in Appendix A, as a graph as well as its natural-language text serialization to demonstrate the applicability of the evaluation strategy in representing real-world medical argumentation.

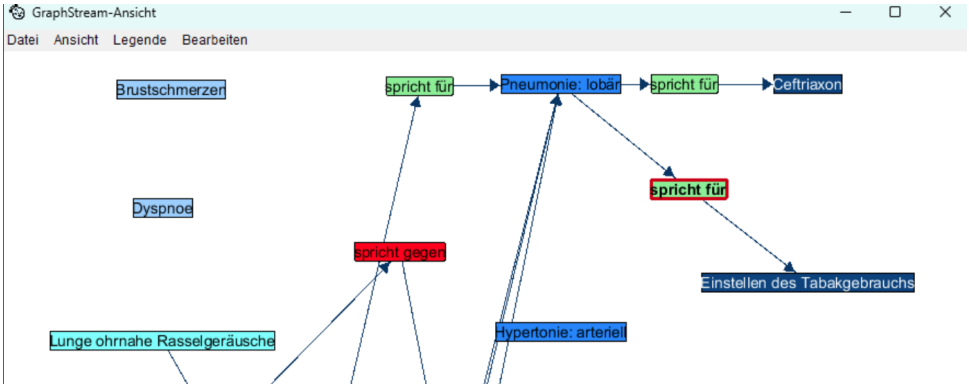

Figure 2: Extract of the Thieme Medical Letter as a Model Graph (German Example).

The user study is planned to be based on the model representation of the Thieme Medical Letter and consists of a Cognitive Walkthrough (CW) [36] to gather feedback of medical and legal experts. The concret action plan of a potential CW is outlined in Appendix B.

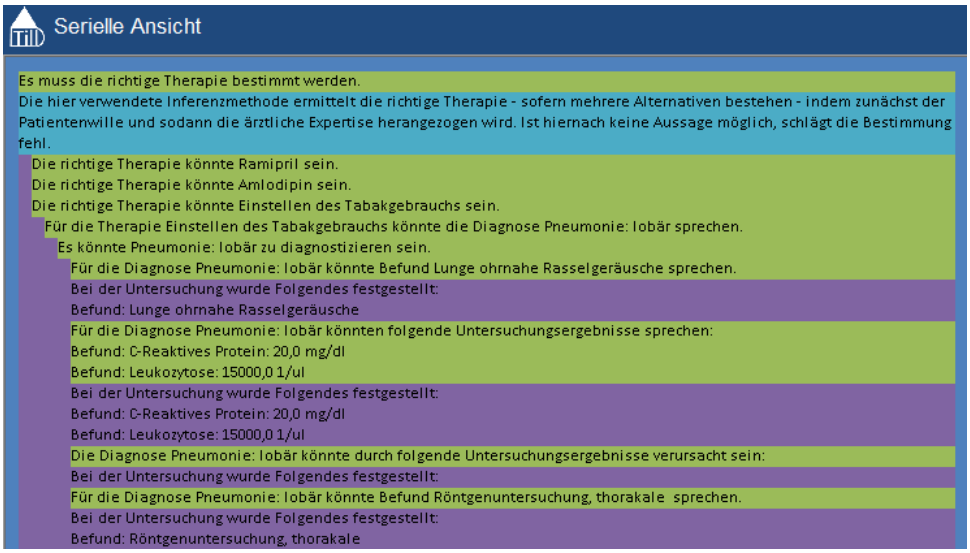

Figure 3: Extract of the Thieme Medical Letter as Serialized Model Graph (German Example).

5. Conclusion and Future Work

This work introduced the model, a medically and legally grounded argumentation model designed to document, structure, visualize, and serialize medical reasoning and decision-making processes as well as a prototype system facilitating it. The research objectives were answered by deriving a medical and legal requirements catalog ($RO1$), grouping the requirements by function to classes ($RO2$), demonstrating an implementation strategy of the model by a mockup representation of a medical letter as graph and serialized natural-language text as well as a component architecture design of a prototype system ($RO3$), and presenting an evaluation strategy to assess the systems usability and usefulness through a user study by CWs with medical and legal experts ($RO4$). Thus, our work lays the foundation for legally-compliant medical documentation of argumentations of decision-making processes.

Future work will focus on a microservice-based implementation of the system to enhance scalability and extensibility for quantitative evaluations, expanding the model by semantics to create a knowledge graph for medical argumentation, and evaluating the system with domain experts to ensure its effectiveness and usability in real-world scenarios. On top of that, extending the system with Artificial Intelligence (AI) capabilities to serialize better natural-language text blocks for legal argumentation as well as to detect medical arguments from health records. Since AI still faces hesitance when incorporating it into software tools, mechanisms such as trustworthiness models as explored in [37] can support adoption.

Declaration on Generative AI

The author(s) used AI (Github Copilot, Deepl, Overleaf, ChatGPT) to assist in the writing and editing of this manuscript as well as to support the creation of PlantUML diagrams, LaTeX source or mockups of the prototype system. All AI-generated content was reviewed and edited by the author(s) to ensure accuracy and coherence with the research objectives. The use of AI was intended to enhance the clarity and quality of the manuscript and source, while maintaining the integrity of the research findings. The ideas are solely those of the author(s) and are not influenced by any AI-generated content and the author(s) take full responsibility for the content.

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A. Methods and Data

The medical letter user in the evaluation section is only as an exemplar to construct a medical individual case argumentation model representation: As a textbook example it does not contain real patient or medical expert personal data, but a concise summary of a medical case, its diagnosis and therapy decisions. The exemplary medical letter is authored by *Georg Thieme Verlag KG*, a German medical and scientific publisher specializing in textbooks, journals and clinical resources for healthcare professionals.

B. Cognitive Walkthrough Tasks

The following simplified actions should be performed during a CW to evaluate the usability and usefulness of the system in a user study with medical and legal experts:

1. The moderator introduced the system and its functionalities
2. User starts the system
3. User imports a pre-defined graph from a RDF file
4. User updates an argument
5. User adds a new argument and relates it to existing arguments
6. User reviews the imported graph in the GUI
7. User serializes the graph to a subsumption-based natural-language text format
8. User reviews the serialized natural-language text in the GUI
9. User exports the updated graph to a RDF file