Argumentation for Traceable Reasoning in Teleexpertise

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Abstract. In this paper we propose a methodological framework based on Artificial Intelligence tools such as Dung's argumentation system in order to provide a decision support tool to the medical professionals performing an act of teleexpertise. The act of teleexpertise permits to medical professionals with different skills and specialities to collaborate remotely for taking suitable decisions for a patient diagnosis or treatment. But in case of litigation, it is important to know where the errors come from and who is the responsible of these errors. So by making the decision making process traceable, it will be easy to identify who is the responsible of the errors that lead to litigation. It is what we try to solve in this paper by proposing a framework coupling semantic modelling and argumentation system. A case study showing an act of teleexpertise to treat an elderly with subdural hematoma is provided in order to illustrate our proposal.

Keywords : Argumentation; Collaboration; Decision Making; Graph of attacks; Teleexpertise.

1 Introduction

Telemedicine consists of performing medical acts remotely by the means of telecommunication and information technologies. It allows the collaboration between different medical professionals and including sometimes the patient in this collaboration in order to make suitable diagnosis and treatment of a disease. Its main purposes [2] are: *establishing a diagnosis, providing for a risky patient a medical monitoring in the context of prevention or a therapeutic monitoring, requiring expert advice, preparing a therapeutic decision, prescribing products, prescribing or performing acts or services and monitoring a patient.* Telemedicine is declined into four main acts: (i) teleconsulatation, (ii) medical telemonitoring, (iii) teleexpertise, (iv) medical teleassistance. The acts are depicted in the Fig. 1.

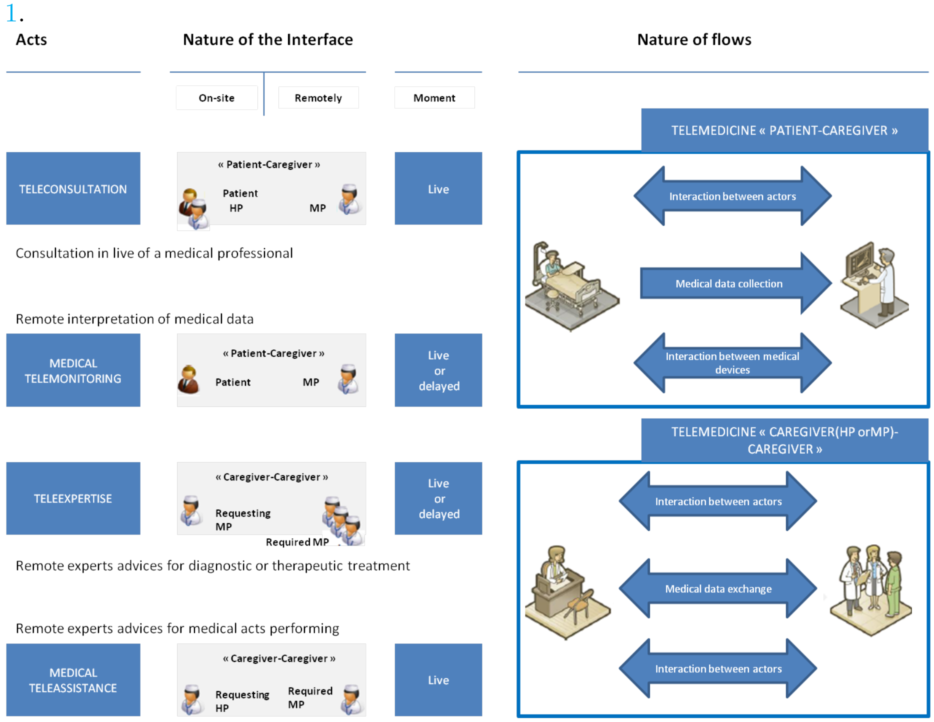

Fig. 1. Main acts of telemedicine [12]

In this paper we are interested in the act of *teleexpertise* that is used by medical professionals to seek remotely advices of one or more of others medical professionals (with different skills or specialities) in order to take and make decisions in a collaborative manner, which will lead to solve medical problems related to a patient. In this act important decisions are taken, so the liability of each stakeholder is engaged. Thus, in case of litigation it is very important to know where the errors come from and who is or are the responsible. The most important thing is to make the reasoning traceable in order to know who said what.

When performing the process of teleexpertise, the advices given by the stakeholders can be conflictual. In this the argumentative logic is used to provide the potential acceptable arguments (advices). The notion of argumentative logic is well explained in [12]. The acceptable arguments are returned to the requesting physician who will make a final decision and store it.

In the following, the paper is divided into four sections namely: some related works, the objective of this work, materials and methods section to show the background of the argumentation logic and the analysis of results with case study section and finally discussion and conclusion sections.

2 Related Works

Many works have been achieved in order to help in finding the liability of each stakeholders providing medical advices in case of litigations, for example Coatrieux et al., 2011 [10] and Bouslimi et al., 2012 [7]. Coatrieux et al. [10] used a watermark technique for guaranteeing the traceability of the digital documents containing medical data. It is the same idea as in [7], where the authors provided a protocol that combines watermarking-encryption techniques and a third party in order to easily bring evidences in case of litigations. Compared to our work, the works achieved in [10] and [7] guarantee traceability by means of security techniques while we guarantee traceability by means of storage and retrieval techniques in a structured manner.

Concerning the argumentation applied to medicine, many works have been also achieved. For example Hunter and Williams, 2012 [16] proposed an aggregating evidence-based approach using argumentation for bringing evidences about the positive and negative effects of medical treatments. Atkinson et al, 2006 [4] used argumentation to show how argumentation can be a value-added asset for a collection of existing information agents. This process is applied to a medical system for reasoning about medical treatments concerning a patient. Jingyan et al., 2008 [17] used argumentation for collaborative practices in medical emergency decision-making processes. Green, 2014 [15] described the role that Artificial Intelligence models based on argumentation plays in medical domain particularly in personalised and participatory medicine. These works based on argumentation are somewhat similar to ours, but the main difference is that, in our work we used structured argumentation [5], which provides an internal structure of arguments involved in the argumentation system.

3 Objectives

In this paper we want to provide a methodological framework taking both into consideration semantic modelling and argumentation in the goal of aiding medical professionals in their decision making process. This work aims to provide innovative solutions coupling conceptual graphs (modelled by CoGui software [1]) and Dung's argumentation system [13] applied to telemedicine, which will contribute to the telemedicine programs' effectiveness [14]. One of the underlying framework is called argumentative logic, which will permit to make the decision making process traceable, in others words, to ensure the reasoning traceability. Thus, by making the decision process traceable, one can identify clearly the advices provided by the medical professionals acting in a given act of teleexpertise.

To be clear, the main purpose of this work is to provide a tool to help create favourable settings for effective interventions of medical professionals in act of teleexpertise in order to know which of their different conflicting advices are potentially acceptable. To do so, we use the Dung's argumentation system in order to model the conflicting arguments and build the acceptable arguments under a given semantics (preferred, stable, ...). These acceptable arguments will be returned to the requested physician after computation. This medical professional, according to some specific parameters (e.g. risk management, preferences, ...) and to the received acceptable advices will make a final decision i.e. choose what advices are useful for the patient's treatment. Furthermore, these chosen advices will be stored for traceability and future expertise. Many works have been achieved in the field of argumentation applied to medicine (e.g. Hunter et Williams, 2012 [16]), but the novel contribution of this work is its positioning in the highly collaborative segment of telemedicine that integrates additional constraints of remote collaborative decision-making in teleexpertise. Another contribution of this work is that the modelling relies on conceptual graphs, which provide an ontological knowledge with underlying logical semantic guaranteeing logical arguments. Moreover, the reasoning is based on graph operations allowing the visualisation of the reasoning steps using mainly the projection operations.

From the point of view of argumentation systems, our work deals with structured argumentation in which argument has internal structure [5] . The different fields in the internal structure of the node are the same like those mentioned in Table 1. Insofar as we combine semantic modelling and argumentation, the use of CoGui software allowing the visualisation of the different steps of the reasoning is important to display and store the satisfactory alternatives to queries. Thus, the output of the argumentative logic is provided in a comprehensible form to the requesting physician to enable him to reach an informed opinion. The storage process guarantees the traceability of reasoning procedures.

4 Materials and Methods

4.1 Acceptability semantics

Above all, we define what is a decision framework (system) [6] also called argumentation based framework AF [3].

Definition 1 *An (argumentation-based) decision framework* AF *is a couple* (A, D) *where:*

- A *is a set of arguments,*
- D *is a set of actions, supposed to be mutually exclusive,*
- action: $A \to D$ *is a function returning the action supported by an argument.*

Definition 2 *From an argumentation-based decision framework* (A, D)*, an equivalent argumentation framework* $AF = (A, Def)$ *is built where:*

- A *is the same set of arguments,*
- $Def \subseteq A \times A$ *is a defeat relation such that* $(\alpha, \beta) \in Def$ *if* $action(\alpha) \neq action(\beta)$.

Definition 3 *Let* $AF = (A, Def)$ *be an argumentation framework, and let* $B \subseteq A$

- B *is conflict-free if there are no* $\alpha, \beta \in B$ *such that* $(\alpha, \beta) \in Def$.

– *B defends an argument α iff $\forall \beta \in A$, if $(\beta, \alpha) \in Def$, then $\exists \gamma \in B$ such that $(\gamma, \beta) \in Def$*

Definition 4 ***(Acceptability semantics)*** *Let $AF = (D, A, Def)$ be a decision system, and B be a conflict-free set of arguments.*

– *B is admissible extension iff it defends any element in B.*
– *B is a preferred extension iff B is a maximal (w.r.t set $\subseteq$) admissible set.*
– *B is a stable extension iff it is a preferred extension that defeats any argument in $A \setminus B$.*

Through these semantics of acceptability, the authors of [3] identify several arguments' status which are depicted below :

Definition 5 ***(Argument status)*** *Let $AF = (D, A, Def)$ be a decision system, and $\varepsilon_1, \ldots, \varepsilon_x$ its extensions under a given semantics. Let $a \in A$.*

– *a is skeptically accepted iff $a \in \varepsilon_i$, $\forall \varepsilon_i$ with $i = 1, \ldots, x$.*
– *a is credulously accepted iff $\exists \varepsilon_i$ such that $a \in \varepsilon_i$.*
– *a is rejected iff $\nexists \varepsilon_i$ such that $a \in \varepsilon_i$.*

The property that is directly connected to the above definition is specified as follows:

Property 1 *Let $AF = (D, A, Def)$ be a decision system, and $\varepsilon_1, \ldots, \varepsilon_x$ its extensions under a given semantics. Let $a \in A$.*

– *a is skeptically accepted iff $a \in \bigcap_{i=1}^{x} \varepsilon_i$*
– *a is rejected iff $a \notin \bigcup_{i=1}^{x} \varepsilon_i$*

4.2 Analysis of results with case study

Case study. Ms D. 87 years old, living alone and having arterial hypertension and myocardial infarction as major medical history diagnosed six months early and treated by Loxen (Nicardipine chlorhydrateR) 50 mg x 2/D, Corversyl (PerindoprilR) 2,5 mg/D, Kardegic (AspirineR) 75 mg/D (midday) and Plavix (ClopidogrelR) 75 mg/D (morning). She is admitted to the emergency department of a local Hospital for a fall at home with an initial brief loss of consciousness and caused by a head trauma. The emergency doctor who received the patient performed a biological examination including a serum electrolytes, a C-reactive Protein (CRP) and a blood count formula, which becomes normal. The computed tomographic (CT) scan performed showed only a cortico-subcortical atrophy without any sign of stroke nor hemorrhage. Thereafter, the patient was allowed to back home with a simple diagnosis of brain contusion. Four days later, Ms D. was admitted again to the emergency department for headaches. Another emergency doctor performed again a second CT scanner, which showed a discrete subdural hematoma. Given that Ms D. is an elderly and it is the second time she was admitted, then she is a risky patient. The second emergency doctor who received the patient decided to perform an act of teleexpertise. To do this, he sought the advices of a geriatrician, a neurosurgeon and the attending physician of the patient. After having taken the required expert advices, the neurosurgical taken advice does not accept surgical indication. The advice provided by the geriatrician is to perform immediately an invasive treatment, so he proposed to make a surgery and the Attending physician of the patient decided to perform invasive treatment (endoscopic surgery in order to assess the level of severity the subdural hematoma) and then to perform a surgery if this latter is severe. Finally the requesting physician (the second emergency doctor) decided to let the patient back home again with the prescription to stop the Plavix and the Kardegic is maintained.

Positioning of the stakeholders. According to the case study above the main stakeholders acting are:

- The **geriatrician**: referring to the patient health state, he would like to perform invasive treatment (endoscopic surgery in order to assess the level of severity the subdural hematoma).
- The **neurosurgeon**: after receiving the CT scanner, he decided that there is no need to perform surgery.
- The second **emergency doctor**: he decided to let the patient back home with the prescription of stopping the Plavix and maintained the Kardegic.
- The **attending physician**: he knows very well his patient's medical history. So he advised to perform endoscopic treatment followed by a surgical intervention if the subdural hematoma is severe.

Modeling information available in structured arguments. To perform a medical act, the medical professionals have the choice between invasive and non-invasive treatment [9], this is resumed in the following:

- **Maximisation of procedures** ($\nearrow Proc$): it consists of performing invasive treatments. It corresponds generally to surgical intervention.
- **Minimisation of procedures** ($\searrow Proc$): it consists of performing non-invasive treatments. In this option, the medical professionals perform medical treatments such drug prescriptions, injection...
- It exists also a third option of treatment called **medical technical treatment**. These treatments are at the frontier of surgery (for example endoscopic treatment). In this paper this option of treatment is modelled by $\rightarrow Proc$.

The advices provided by the different medical professionals acting in this act of teleexpertise are illustrated in the Table 1. In this table we can note that the column "Concerns" is redundant because a graph of attacks is built only for a group of stakeholders with the same "concern". It is for this reason that "ensure a good quality of life for this elderly patient" is redundant. It is the requesting physician who specifies the "concern" in his request of teleexpertise. So all the stakeholders must give their advices on the basis on this "concern".

In front of the clinical case described in the section 4.2, the system will be used to ask remote advices. These advices are asked by the emergency doctor who receives the patient when she was admitted again. When asking for the teleexpertise, the requesting physician (the emergency doctor) designates the required physicians by their specialities. On the basis of the patient medical record, he chooses a Geriatrician, a Neurosurgeon and the Attending physician of the patient while accompanying his request with his suggestion (advice) and the concern. Each of the required physicians can express their advices in a structured manner according to the field (stakeholder, reason, concern, goal) of the Table 1. Then a server gathers all the advices as shown in the Table 1, it translates them in conceptual graphs, builds the graph of attacks and then computes the argumentative logic to know which arguments (advices) are potentially acceptable under a given semantics. Therefore, the output of the argumentative logic is sent to the requesting physician who is empowered to make the final decision that is stored in the server for potential subsequent verifications.

Table 1. Stakeholders argumentation

	Stakeholders	**Reasons**	**Options**	**Concerns**	**Goals**
1	Geriatrician	α = He would like to perform immediately an invasive treatment, he proposed to make a surgery	$\nearrow$ *Proc*	Ensuring a good quality of life for this elderly patient	Removing the subdural hematoma even if it is not very severe.
2	Neurosurgeon	β = He decided that there is no need to perform surgery.	$\searrow$ *Proc*	Ensuring a good quality of life for this elderly patient	Preventing the side effects after surgery.
3	Emergency doctor	δ = He decided to let the patient back home with the prescription of stopping the Plavix and maintained the Kardegic.	$\searrow$ *Proc*	Ensuring a good quality of life for this elderly patient	Avoiding the blood coagulation by stopping the use of Plavix.
4	Attending physician	γ = He would like to perform invasive treatment (endoscopic surgery in order to assess the level of severity the subdural hematoma) and perform a surgery if this latter is severe.	$\rightarrow Proc \wedge \nearrow Proc$	Ensuring a good quality of life for this elderly patient	Assessing the level of severity of the subdural hematoma and performing a surgery if needed.

Graph of attacks. The graph of attacks (Fig. 2) is a set of nodes linked between them by oriented arcs. It is used in the argumentation system theory [13] to represent the interaction existing between arguments.

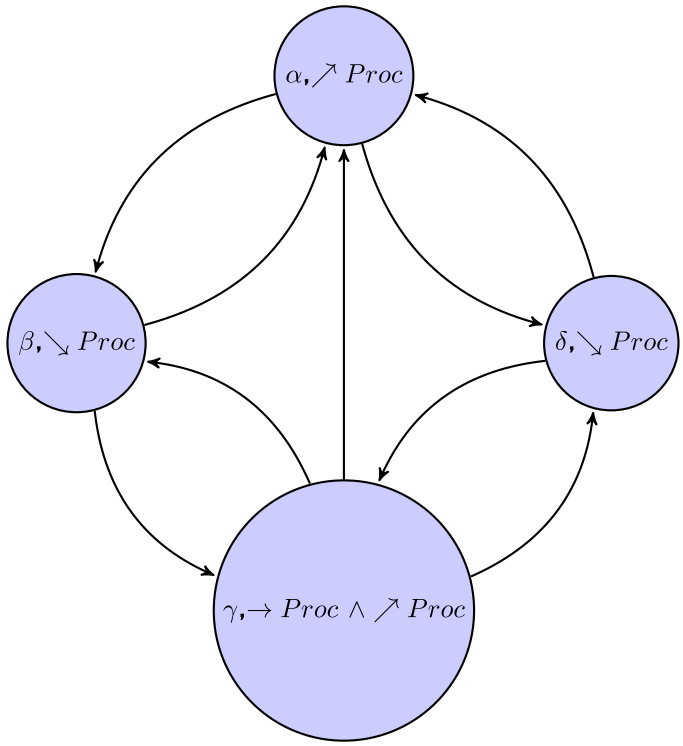

Fig. 2. Graph of attacks

Decision making process. The different extensions below are determined according the definitions above applied to the graph of attacks Fig. 2.

- **Determination of conflict-free sets** : the conflict-free sets are : $\{\emptyset\}$, $\{\alpha\}$, $\{\beta\}$, $\{\delta\}$, $\{\gamma\}$, $\{\beta, \delta\}$.
- **Determination of admissible extensions** : the admissible extensions identified are : ε_1=$\{\emptyset\}$, ε_2=$\{\beta\}$, ε_3=$\{\delta\}$, ε_3=$\{\gamma\}$, ε_4=$\{\beta, \delta\}$.
- **Determination of preferred extensions** : According to the definition above the preferred extensions that we can have are: ε_3=$\{\gamma\}$ and ε_4=$\{\beta, \delta\}$

So by the definition above (argument's status) and under the preferred semantics, the arguments β, γ and δ are credulously accepted. These arguments are then returned to the requesting physician for final decision. This final decision will be taken under some additional parameters. So by considering these parameters, the requesting physicians can decide to perform non-invasive treatment ($\searrow Proc$) or invasive and medical technical treatments ($\rightarrow Proc \wedge \nearrow Proc$).

5 Discussions

The provided framework called argumentative logic based on Dung's argumentation system guarantees the traceability on the reasoning in the decision making process while permitting efficient collaboration between medical professionals. Thus by the traceability, in case of litigation the responsibility of each medical professional could be easily identified.

The use of Artificial Intelligence tool in the decision making process is taking a big part in health domain generally and in telemedicine particularly. For example the PANDORA system [8], used as learning tool in crisis environment (e.g. health crisis) for decision makers with underlying Artificial Intelligence tools. Comparing this one to our work, we can say that our proposal can also be used as a learning tool since the accepted decisions are stored in a database [12] for future acts of teleexpertise.

6 Conclusion

In this paper we proposed a methodological framework based on Artificial Intelligence tools namely the Dung's argumentation system [13] in order to aid the medical professionals in their decision making process while ensuring the reasoning traceability. This traceability will permit to identify the responsible of medical errors in case of litigation [11].

In further work, we will implement our work to verify it feasibility. This implementation will permit to the instantiation of the proposed argumentation system in conceptual graphs in which we can represent rules and constraints. Also given that CoGui software provides an API[1] based on JAVA, it will be possible to easily develop a kind of middleware to retrieve remotely medical information to build the graphs of attacks in conceptual graph formalism.

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