Collaborative modelling: organize, report and understand an experts' group debate

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Abstract

In an organization, such as a company, decision making is often supported by input from a collective of experts who exchange views on the matter at hand during meetings held under the authority of a manager. During these meetings, experts exchange arguments to reach a solution, to come to a final choice. In such a case the manager is responsible for taking the final decision. But, as the manager is not necessarily an expert, he needs to be helped in order to analyse and understand the final decision of the group. This paper introduces a formal framework to capture the arguments of the experts during the debate as well as the relationships between the arguments. By using this framework, the manager could analyse the arguments that led to the decision.

1. Introduction

Recently, there have been significant advances in process definition that help to ensure correctness and reliability of models and simulations. Verification and validation provide justification, throughout the whole life-cycle, of why identified models, simulations, underlying data, outcomes and capabilities are believed to be acceptable. The goal of these justifications is to support stakeholders in their acceptance decision-making process on the utilization of Modeling and Simulation. Stevenson defined quality assurance of simulation as a set of justifications: "Knowledge requires justification; quality assurance is basically knowledge justification" [16]. If a part of justifications can be expressed in a formal system, most of the elements leading to confidence in a simulation are objective, but not demonstrable in the mathematical sense.

In this paper, we want to address a particular problem: justification of a design choice by a committee of experts. This problem is a part of verification and validation problem of collaborative modeling. In nowadays companies, decision making is often supported by input from a collective of experts who exchange views on the matter at hand during meetings. During these meetings, experts exchange arguments to reach a solution, to come to a final choice. These meetings may occur face-to-face or virtually via collaborative tools, over a few days or a longer period of time. In such a case a decision maker, for instance a manager, is responsible for taking the final decision. But because the decision maker is not necessarily an expert, he has to be helped in order to analyze and understand the final decision of the group. We propose to provide him with a framework that captures the arguments of the experts during the debate as well as the relationships between the arguments. This framework should not only capture the arguments of experts but also how they are structured. Finally, it should explain why a thesis has been accepted. The purpose of such a framework is double: (i) understand how the experts group made the decision, (ii) keep track of the arguments to have a history.

This work is part of the CRESCENDO European project. The ambition of CRESCENDO is to make a step change in the way that Modeling and Simulation activities are carried out, by multi-disciplinary teams working as part of a collaborative enterprise. The project is a consortium of 59 partners. One aim of the project is the organization of Modeling and Simulation activities for designing and developing an aeronautical product. In this context, it often occurs that a large number of experts from different companies, and sometimes experts on different topics, take part in a panel discussion.

A first motivation is having a framework to keep a record of meetings can be very interesting for the constitution of a corporate memory. As highlighted by Kalawsky [10] in the research grand challenge "Through life information and knowledge management", during the simulation's lifecycle, there is a danger that explanation of design decisions are forgotten. The experts who designed a system are likely to have moved to another job or even to have retired and nobody knows exactly why the design emerged as it did. This is why a framework to report meetings should record evidence given by the experts to motivate their choices (evidence can consist of mathematical model, academic articles, simulation results, demonstration, old project reference, business reason . . .).

Furthermore, very often, when a project is over, no one remembers why certain choices have been made, mainly because people have left the company or have forgotten and because the reasons for decisions have not been recorded. Keeping records of the arguments would avoid having the same discussion all over again, with the same arguments. In addition, recording the debate would allow the discussions to be resumed and experts could introduce new arguments if they feel the need to. The use of a corporate memory, to understand the choices that were done, is crucial. As Fletcher et al. [7] says: 90% of design activities are based on existing design. We do not address here the problem of the design reuse, but the problem of understanding experts' design choices. However, methods and tools exist today for the more generic problem of design reuse (see Kim et al. [11]).

Of course, we could use natural language in order to report a face-to-face debate or to record an expert's assertion in an online collaborative debate, but the natural language is poorly structured, it is very difficult to track information, and relation between experts' assertions are not clear. The use of graphical notations in engineer science, like the Unified Modeling Language (UML), is common now. More recently, graphical notations appeared in system safety. Languages like the Goal Structuring Notation (GSN) are used in safety [4] to improve the comprehension of the safety arguments amongst stakeholders.

The key point is: having a visual representation of a debate allows its better understanding. Twardy [18] shows how the use of graphical tools helps students to better understand the links between the arguments. In the same idea, Verheij, in [19], examines the undeniable contributions that visualization tools could have to structure argumentation in legal field. We can also cite Bob Horn's work [9] on information mapping and how a visual representation clarifies a debate. He has proposed, for example, a clear graphical representation which summarizes the positions of 380 philosophers, computer, cognitive and mathematical scientists on the question "Can computers think?" He proposes an "Arguments Map" which explains how 700 arguments are related to one another.

Our aim in this paper, is to define a framework as formal as possible in order to provide well-founded analyses of a debate.

2. Example: collaborative design choice

Consider this example: a discussion has been organized between five experts on the selection of the right numerical model to simulate the noise generated by a jet engine in the airplane cabin. The conclusion was that *noise should be modelled as a non-uniform flow using the Euler equations*. During the debate:

- expert 1 gave several examples in which noise has been modelled as a non-uniform flow using Euler equations, and argued that this was a good choice in each case;
- expert 4 agreed with expert 1;
- expert 2 gave academic references on the Euler equations applied to this kind of problem;
- expert 5 was not convinced by the references;
- expert 3 replied to 1 and 2 that the problem was not confined only to the noise generated inside the cabin, but also to the jet noise outside since both are heard inside the cabin, he gave scientific results;
- based on scientific results, expert 2 argued that using a non-uniform flow model is a good representation of the noise both inside and outside the cabin;
- in agreement with the expert 2, the expert 5 reports a former project of the company where this approach has been used;
- expert 4 replied that, for this project (business reason), modelling non uniform flow was too time consuming.

A discussion report like the previous one is difficult to understand and not recoverable as part of the evolution of a project. The ins and outs are not necessarily clear. And here, we have a very simple example with only a few arguments and a few links between them.

3. Argumentation

3.1 A brief state of the art

Many formal models of argumentation have been defined, mainly in Artificial Intelligence field. In some approaches, logic is used to model the notion of argument. More specifically, the notion of argument is defined from the notion of logical implication. Besnard and Hunter [3] consider a given set of formulas Δ and define an argument as a pair of formulas in Δ, $\langle A, B\rangle$ such that the support , A, is a non contradictory formula which logically implies the conclusion B, and this, in a minimal way. An argument undercuts another one when conclusion of the first one contradicts the support of the other. The main notion is the notion of argument tree. An argument tree describes the various ways an argument can be challenged, as well as how the counter-arguments to the initial argument can themselves be challenged, and so on recursively.

Some other formal approaches to argumentation are based on Dung's work [6] Dung's argumentation framework defines an argument system as a pair $\langle A, R\rangle$ in which A is a finite set of arguments and $R \in A \times A$ is the attack relationship between arguments. Dung gives several formal semantics to an argument system so that an argument x in A can be accepted. Dung's work has been the basis of many researches. For instance, [5] Cayrol and Lagasquié-Chiex introduce "graduality" in the selection of the best arguments. In [2], Bench-Capon et al. propose the notion of "value-based argumentation system" by adding values to arguments in an argument system in order to take into account the public to whom the argumentation is addressed.

Recently, [1], Amgoud and Dupin de Saint Cyr aim at studying the quality of a dialog. In this work, arguments are composed by a support and a conclusion and are linked, like in Dung's formalism, by an attack relation. A dialog is a sequence of "moves", a move being defined by the agent that utters the move, the set of agents to which the move is addressed and the argument which is uttered. In a dialog, arguments are weighted. From these, the authors analyse the quality of the exchanged arguments during a dialog, the agent's behaviour and the properties of the dialog itself.

This last work is particularly interesting because it is based more or less on the same assumptions than our own work: it considers a dialog between agents which utter arguments. However, it does not consider the corroborative relation we need.

3.2 The concepts we need

Firstly, the debate ends because a decision is taken by the group of experts. We call it the *conclusion*. In the example given in section I, the conclusion is: "noise should be modelled as a non-uniform flow using the Euler equations". Secondly, *arguments* have been exchanged between experts. More precisely, at each stage of the discussion, an *agent* (who is one of the experts) utters an *assertion* and sometimes provides *evidence* to support it.

The scientific community who studies the notion of arguments and dialogue is the community of argumentation theory. If we refer at the work of Toulmin[17], he defines the notion of *claim*, a "conclusion whose merits we are seeking to establish". This definition is close to our *assertion*. In the same idea, what we call evidence corresponds to notion of data and backing. Furthermore, the notion of *evidence* corresponds to Toulmin's notion of *data* and *backing*. Indeed, for Toulmin, *data* are "the facts we appeal to as a foundation for the claim" and *backing* is a kind of justification like a law or a statistical result. References to scientific articles, business practices, examples, physical contingencies are evidence as well. In the example, expert 2 provides bibliographic references as evidence for his assertion.

Another point is the relation between arguments. Argumentation theory studies in detail the notions of *corroborate* and *attack*. To be simple, and a little bit naïve, in a discussion, any argument *corroborates* or *attacks* one or several previously presented arguments. For instance, when expert 4 says that he agrees with expert 1, he corroborates expert 1's view, but then expert 1's view is attacked by expert 3's assertion. Of course, to define all relations between arguments with these two relations is restrictive, but our aim is to define a framework as simple as possible. An argumentation structuring technique like [12] propose a more complex model with more arguments objects and relations.

Finally, a key point is that, in a debate there are several *agents* that shows that we are clearly in the context of dialogical argumentation.

It should be noted that here all the arguments are relevant to the discussion since they corroborate or attack a previous argument. However, in general, an expert could assert something that is not related to the debate. This will be excluded in this present work.

4. A formal framework to report a debate

This section presents the formal framework we define in order to report a debate.

4.1 Debate structure

We consider a language L (for instance the natural language) the sentences of which are called propositions and are used to model arguments. We also consider a set A of agents used to model the experts.

An argument is defined as triple in which the first item is an expert assertion represented by a proposition, the second item is an agent (the one who came up with the argument), and the third item is a list of the evidence given by the agent to support the assertion.

Definition (argument).
An argument as a triplet $\langle \Psi, a, e \rangle$ where

- Ψ is a proposition ;
- $a \in A$ is an agent ;
- e is set of proposition, possibly empty (denoted $\emptyset$).

Example. In our introduction example, an argument could be ⟨ "modelling uniform flow was too time consuming", *Expert1*, {*business reason*} ⟩.

Definition (conclusion).
A conclusion is an argument $\langle \Psi, A, \emptyset \rangle$.
Example. The conclusion of our debate is ⟨ "noise should be modelled as a non-uniform flow using the Euler equations", {*Expert1, . . . Expert5*}, $\emptyset$⟩.

As seen previously, we consider that in the debate, arguments are linked by two types of binary relations. The relation is a corroborating relation when an argument is given to reinforce another one. The relation is an attacking relation when an argument is given to attack another argument. A debate is modelled by the notion of argumentation defined as follows:
Definition (argumentation).
An argumentation is a connected directed acyclic graph[1]
$Arg = (V, E)$ with:

- vertex in V are arguments ;
- there is one and only one sink[2] which is a conclusion ;
- each edge in E between $v1$ and $v2$ is labelled with + if $v1$ corroborates $v2$;
- each edge in E between $v1$ and $v2$ is labelled with $-$ if $v1$ attacks $v2$;
- Two vertices are connected by at most one edge.

We define two relations between arguments, $\overset{+}{\rightarrow}$ and $\overset{-}{\rightarrow}$. These two relations aim to represent a corroborating and an attacking relation.
Definition.
Consider an argumentation $Arg = (V, E)$. Let $v1 \in V$ and $v2 \in V$.

- $v1 \overset{+}{\rightarrow} v2$ iff the edge between $v1$ and $v2$ is labelled $+$.
- $v1 \overset{-}{\rightarrow} v2$ iff the edge between $v1$ and $v2$ is labelled $-$.

Figure1 is the graphical representation of the argumentation corresponding to our example.

[1]A *DAG* (directed acyclic graph) is a graph $G = (V, E)$ where V is a set of vertices, or nodes, and E set of directed edges, each edge connecting one vertex to another, such that there is no cycle.
[2]A *sink* is a particular node with only incoming edges.

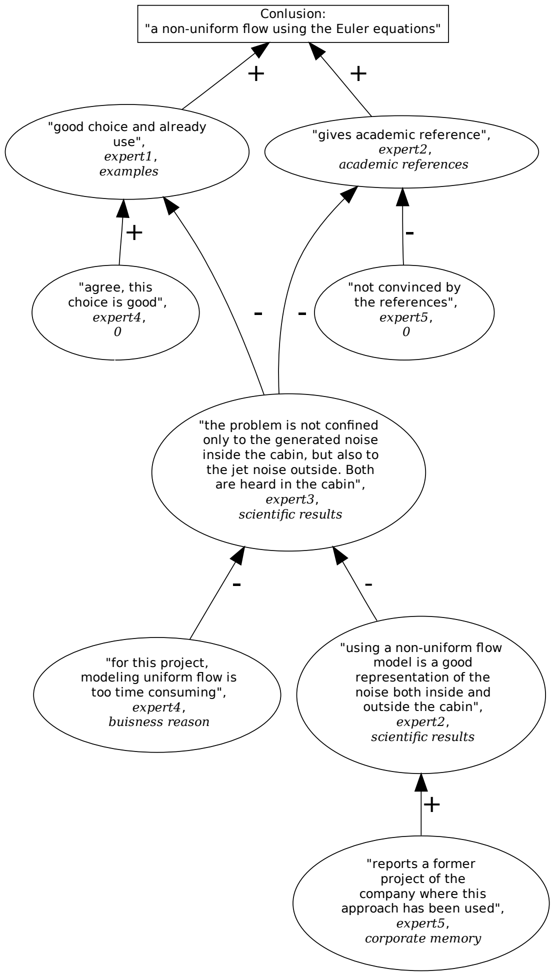

Figure 1: Argumentation structure example

Note that the graph is connected. There is no vertex without any connection (edge) with another vertex. If it did, it would mean that an agent said something completely unrelated to anything that was said during the debate, in other words we would have an argument irrelevant. In this work, by hypothesis, we consider that all arguments are relevant to the debate.

5. Argumentation analysis

We propose an automatic analysis of an argumentation in order to understand the underlying debate and its conclusion as well. For that, we define a set of questions that can be automatically answered to understand a group decision. Notice that here, we focus on the dialog properties, not on the expert validity.

In this paper, we focus on the three following questions:

1. Are there weak arguments? (i.e. not supported by evidence)?

2. Are there assertions from the same expert both in favour of the conclusion and against it ?

3. How valid is the conclusion?

5.1 Weak argument

Of course, the expertise of the experts is obviously relevant, otherwise we could assume they were not invited in the debate. But experts are not infallible. In such debates, there is a risk of an *argumentum ad verecundiam* (appeal to authority), which means considering an argument correct as made by a person commonly regarded as authoritative.

To prevent that, experts could give evidences. Evidence is an hyperlink to resources such as articles, specifications, tests, books, etc. It is possible to add to arguments the list of the evidence given by the expert to support the assertion. The obligation of giving evidence or not for each argument depends on the debate policy. We therefore propose to identify which of the arguments are not supported by evidence. The aim here is not to refute such argument, but just to identify it in the debate report.

An argument is weak if it is not supported by any evidence. This idea is close to one of the Walton [21] Backup Evidence Critical Questions: "Is expert's assertion based on evidence?", but here this is only a structural test. We do not look the quality or the credibility of the evidence, just if the argument is supported by evidence or not.
Definition (weakness).
An argument arg is weak if and only if $arg = \langle \Psi, a, \emptyset \rangle$ where a is an agent.
Example. For instance, argument $\langle$"not convinced by the references"$, 5, \emptyset \rangle$ is weak because expert 5's assertion has no evidence to support it.

5.2 Consistency of expert's assertions

During a debate, an expert could hold two arguments that relate differently to the conclusion. It is not nonsense. There are two rational explanations for this. First, an agent may attack the conclusion of the debate, but it may disagree with an attacking argument. As a common example, one may disagree with the hypothesis of an expert, but may attack some arguments against the expert because, for him, they are irrelevant. Second, during the debate, an agent was convinced by other agents. In this case, even if he had uttered cons arguments in the beginning, he can utter pro arguments in the end.

Note that in order to reach a consensus, a group argumentation framework must accept that agents change their mind during the debate. Otherwise, it would mean that every agent stays on his position and, if experts do not agree that no consensus is possible.
Definition (assertions consistency).
We define the predicate *positionchange* so that for an agent a, $positionchange(a)$ iff there are two arguments $arg_1 = \langle \Psi_1, a, e_1 \rangle$ and $arg_2 = \langle \Psi_2, a, e_2 \rangle$ such that $pro(arg_1)$ and $cons(arg_2)$.
Example. After having heard expert 2, expert 5, who is against to model noise as a uniform flow, gives an argument pro: a former project of the company had already used this method. Expert 5 changed his position in regard with the conclusion.

5.3 Degree of validity of the conclusion

Here, we would like to offer the manager means that can check if the conclusion of the debate agrees with some decision procedure he had in mind or implicitly accepted by the organization he belongs to.

There are different decision procedures that may be accepted: a procedure according to which a conclusion is valid if the number of pros arguments that are not attacked nor supported are greater that the number of cons that are not attacked nor supported; a procedure according to which a conclusion is valid if all cons arguments are attacked; a procedure according to which a conclusion is valid if in which most cons arguments are attacked; etc.

Each decision procedure defines what is the valid conclusion and each decision procedure could lead to a question the manager could ask.

We define, for instance, a validity degree of a conclusion as the number of sources[3] against the conclusion over the number of sources. We subtract the result of the operation to 1 to conform to the intuition: the higher the degree validity, the lesser the conclusion it attacks.
Definition (conclusion degree of validity).
Consider an argumentation, its conclusion degree of validity is defined by:

$$d = 1 - \frac{\mid \{source(v) \wedge cons(v)\} \mid}{\mid \{source(v)\} \mid}$$

[3] A source is a vertex with no incoming edge. $source(v)$ is true iff the vertex v is a source of the argumentation DAG.

Example. The argument corresponding to experts 5's utterance is the only leave which is a cons argument. Thus the validity degree of the conclusion is: 3/4.

6. Graphical representation of argumentation: visualisation tools

During the last decade, an increasing number of visual software have been developed to organize, structure and visualize ideas, tasks and concepts (like mind maps, concept maps, fishbone diagrams, etc.). Using graphics to support reasoning is not new, but the progress of human-computer interaction played a critical role in this evolution.

Graphical representations of argumentation have been introduced a long time ago. According to Reed et al.[13] the first example of diagrams used to illustrate an argumentation is provided by Richard Wately in his book "Elements of Logic". While the first diagrams were drawn with a pencil, graphical diagramming tools appeared with computers and advances in human computer interfaces. Nowadays, a lot of tools try to represent argumentation. In most of these tools, the argument map is a diagram, with boxes and arrows representing the structure of an argument.

For instance, Carneades[4][8] is software based on a formal mathematical model for argumentation. Carneades provide argument evaluation in respect of various argumentation schemes. In the field of legal argumentation[20] describes a non-monotonic logic, DefLog, and an associated tool Argumed. The software Araucaria[5][14] was tested in 2004[15] by the Magistrate Court of Justice in Ontario, Canada. The results of this study were two-fold. In simple cases with few arguments involved, the software allowed the magistrate to quickly see what critical questions to answer. In complex cases, some judges found the software useful for clarifying all the aspects of the case and links between them. Araucaria support text analysing and supports the user in constructing an argumentation diagram. The diagram is a tree structure and it is possible to translating them in Toulmin diagram or Wigmore diagram. All these tools are designed to evaluate an argumentation based argumentation schemes. If they provide support in the context of understanding an argumentation, they are not really adapted to our problem. Our goal here is not modelize the structure of arguments, as the case in legal argumentation, but reporting a debate. Moreover, none of these software has the notion of agents as we have with the experts.

There are a lot of software for visual representation of the structure of an argument. Tools like Argunet[6], Compedium[7] (a graphical IBIS-type tool [12]) or commercial software bCisive[8] provide a visual environment for creating collaboration diagrams such as the map argument. They have a lot of fancy features and they clearly address problems like collaborative work, argumentation report and corporate memory.

Unfortunately, these software are mostly graphic and they do not provide a formal structural analysis. This is why we have developed a prototype of a graphical tool based on our framework.

7. Conclusion

We introduce a formal framework that captures the expert arguments during the debate as well as the relationships between them. By using this framework, the manager could analyse the arguments that led to the decision. He could then check if the arguments are evidence-based, if the decision is sufficiently well supported by the arguments, and if some of the expert's opinion had changed their during the debate, etc.

Future work could focus on adding qualitative or quantitative information on each arguments, taking into account the domain of expertise of each expert. Another interesting development could be to describe the use of such debate reports all along the development process of a program, supporting or challenging existing justifications with data or knowledge collected later, after architectural choices for instance.

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[4] http://carneades.berlios.de
[5] http://araucaria.computing.dundee.ac.uk/doku.php
[6] http://www.argunet.org
[7] http://compendium.open.ac.uk/institute
[8] http://www.bcisiveonline.com

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