Arguing over Actions that Involve Multiple Criteria: A Critical Review

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Abstract. There has recently been many proposals to adopt an argumentative approach to decision-making. As the underlying assumptions made in these different approaches are not always clearly stated, we review these works, taking a more classical decision theory perspective, more precisely a multicriteria perspective. It appears that these approaches seem to have much to offer to decision models, because they allow a great expressivity in the specification of agents' preferences, because they naturally cater for partial specification of preferences, and because they make explicit many aspects that are usually somewhat hidden in decision models. On the other hand, the typically intrinsic evaluation used in these approaches is not always the most appropriate, and it is not always clear how the multicriteria feature is taken into account when it comes to aggregating several arguments that may potentially interact.

1 Introduction

Decision-support systems aim at helping the user to shape a problem situation, formulate a problem and possibly try to establish a viable solution to it. Under such a perspective decision aiding can be seen as the construction of the reasons for which an action is considered a "solution to a problem" rather than the solution itself [Tso07]. Indeed the problem of decisions *accountability* is almost as important as the decision itself. Decision support can therefore be seen as an activity aiming to construct arguments through which a decision maker will convince first herself and then other actors involved in a problem situation that "that action" is the best one (we are not going to discuss the rationality hypotheses about "best" here). Decision Theory and Multiple Criteria Decision Analysis have focussed on such issues for a long time, but more on how this "best solution" should be established and less on how a decision maker should be convinced about that (for exceptions on that see [BMP+00, BS02]).

More recently, in the field of artificial intelligence, argumentation has been put forward as a very general approach allowing to support different kinds of decision-making [BG96, PV02, Pol87, PJ98, AP06]. Typically, one will construct for each possible decision (alternative) a set of positive arguments, and a set of negative arguments. However, decision-makers do not simply *list* pro and cons: they exchange arguments, some of them interacting with others, attacking or reinstalling previous arguments put forward (by the other party, or sometimes indeed by itself). Distinguishing what eventually should count as acceptable arguments has been the study of numerous studies, and necessitates to value the arguments. Cayrol and Lagasquie-Schiex [CLS05] distinguish *intrinsic* valuation of arguments (without any consideration for the other arguments –for instance it may be based on the credibility of the source), and *interaction-based valuation* of arguments (simply resulting of the interactions between arguments –for instance some may be better supported than others, etc.). In the seminal work of Dung [Dun95], different semantics are proposed, which interpret differently what (sets of, in this case) arguments should be considered acceptable, only based on their interaction-based valuation. More recently, some approaches propose to take both aspects into account, see *e.g.* [KP98]. Once the valuation has been made, it is then possible to select the acceptable arguments. Usually, only a crisp selection is allowed: arguments are acceptable or not; however a more gradual acceptability is also possible [CLS05]. Our objective in this paper is to clarify the connections between argumentation and decision-making, and more precisely to inspect the recent proposals that have been put forward to handle (multi-criteria) decision-making in an argumentative framework.

The rest of this paper is as follows. In Section 2, we examine more carefully what it means to argue for an action, especially when different points of view can be considered to assess that action. We confront the different proposals put forward in the literature to our multicriteria perspective and discuss some hidden assumptions that they make. In Section 3, we move on to the following step by inspecting how aggregation can then be performed. Section 4 concludes.

2 Arguing over Actions

Before reviewing the literature on argument-based decision making (focusing especially on how they account for the fact that different criteria may be involved), we start by briefly recalling what makes decision over actions different from decision over beliefs,

2.1 Arguments meet beliefs, actions, and "points of view"

Argumentation is usually conceived as a process for handling (potentially conflicting) *beliefs*. In AI, many systems have been proposed that allow to capture the defeasible nature of this kind of reasoning. Under this perspective, the basic building block (the argument) can typically be defined as a premise/conclusion pair, whereby you state that this conclusion should be reached under these premises. What is discussed here is the truth-value of the conclusion, so an argument supporting a conclusion basically asserts some evidence to believe that this conclusion holds.

When it comes to decision-making though, this rather crude argument scheme needs to be refined. Indeed, as it has been recognized for a long-time now, a significant difference exists between argumentation for beliefs and argumentation for actions [FP97, FP98]. This is best explained by means of a simple example, inspired by [FP97]. Saying that some symptoms "support" a given diagnosis, and that this diagnosis in turn "support" a given medication are two different things. The first —epistemic— argument is typically a defeasible proof of the doctor's diagnosis. The latter —practical— argument is a recommendation that this course of action should be chosen, which can for instance be defeated by the fact that other medications may turn out to be better options. So the same word "support" must be interpreted differently.

But we need to make more precise what is exactly meant by "an argument is in favour of an action a". The intuitive reading is that action a will have "good consequences". So we must first somehow *valuate* the outcome of the action. In decision models, this would typically be done by using an ordered scale defining the different values that can be used to assess the action (for instance, marks from 0 to 20 for students). Now what counts as a positive or negative outcome is specific to each agent, and depends of its (subjective) preferences. That is, you must classify the outcome of the actions. In decision models, one classical approach is that the agent uses an evaluation scale and specify a frontier, that is, a neutral point (or zone), thus inducing a *bipolar scale*. This will in turn allow us to determine what counts as an argument pro, or against, the action.

Let us suppose that we want to select a candidate for a given position, and that we have a number of candidates applying for it. We need to evaluate the outcome of each possible action, that is, how good is the situation induced by accepting each given candidate. For instance, a desired consequence is to have a strong enough candidate as far as academic level is concerned. Let us suppose that this is assessed by using a bipolar scale referring to marks, where 12 stands for our neutral point. Then, we could say that according to "marks", we have an argument in favour of accepting this candidate if its mark is more than 12.

Intuitively, as we said before, performing an action will bring about a state of the world which will be judged desirable or not. In general however, it is possible that you may have different valuations that you assign to a given action, depending on different points of view that you take to evaluate that action. Very often, these different valuations cannot be merged into a single point of view. This has been recognized in particular in multi-criteria decision-making, where a criterion is regarded as a point of view against which it is possible to compare different actions. Now, the definition of a neutral point for each point of view defines what we shall call here a *neutral action*, a special action against which each action can be compared.

2.2 Discussion of existing approaches

In [FP97], Fox and Parsons proposed one of the first account that tried to advocate an argumentative approach to decision-making, building on Fox's earlier work [FBB80]. They recognize and clearly state what makes argumentation for actions different from argumentation for beliefs, and put forward the following argument scheme:

Fox and Parsons' Argument Scheme
We should perform A (A has positive expected value)
Whose effects will lead to the condition C
Which has a positive value

As explained by Fox and Parsons, the advantage of this representation is that it makes explicit three inference steps: (i) that C will indeed result from action A, (ii) that C has some positive value, and eventually (iii) that A has a positive expected value. Clearly, steps (ii) and (iii) requires additional information in order to be able to assign values to situations, and to decide whether the action has indeed a positive expected value. The valuation of the condition is subjective (dependent of the agent's preference), and represented here by "labelling the proposition describing C with a sign drawn from a dictionary", which can be qualitative or not and plays the role of a scale. Interestingly, they also allow for different points of view over which values can be assigned.

So for instance, opting for a given candidate (say a) could lead to an outcome where the chosen candidate has a mark of 14 (this would be captured by the first epistemical step e_1 of the scheme, where ga stands for the justification of this step). Together with the two following steps, this could be represented with this scheme as follows:

$$\begin{array}{lll} chose_a \rightarrow mark = 14 : ga & : + & e_1 \\ mark = 14 \quad\quad\quad\quad : va & : + & v_1 \\ chose_a \quad\quad\quad\quad\quad : (e_1, v1) & : + & ev_1 \end{array}$$

The last step concludes that this action has a positive expected value. More interestingly, the second step (v_1) means that the condition $mark = 14$ is positively evaluated by our agent (noted by symbol +) (it then counts as a positive argument), where va is the justification for this value assignment. Although this aspect is not deeply explored in the paper, a very interesting feature of this approach is then that it makes explicit the grounds allowing to assign this value to this condition: what may count ha obvious candidates to justify this value assignment, if we take the view of the multicriteria-decision approach, would be the user's preferences ("I consider that the mark is good from 12"), as well as the preference model used ("I consider this to be a positive argument as long as it is beyond the limit previously stated").

But we could also directly encode within this scheme that opting for a given candidate would lead to an outcome where the condition that the chosen candidate has a mark over 12 is satisfied, a fact that we consider positive. This could be represented as follows (the last step does not vary)

$$\begin{array}{l} chose_a \rightarrow mark \geq 12 : ga : + e_1 \\ mark \geq 12 \quad\quad\quad\quad : va : + v_1 \end{array}$$

meaning that the condition $mark \geq 12$ is positively evaluated by our agent (noted by symbol +) (it then counts as a positive argument), where va is the justification for this value assignment. In this case, the nature of this justification is less clear, for it leads to support the agent's preferences.

These two alternative ways of representing argument schemes about actions seem somewhat unsatisfactory. On the one hand, chosing to directly represent the neutral action drawn from the agent's preferences drops the relation linking an action and its consequences. On the other hand, not representing it assumes it is somehow encoded within a "value assignment" mechanism. Finally, this approach does not really acknowledge that actions themselves can be evaluated against a number of meaningful, predefined, dimensions: in fact, each condition induces a new dimension against which the action can be evaluated.

One of the most convincing proposal recently put forward to account for argument-based decision-making is the one by Atkinson et al. [ABCM06, Atk06]. They propose an extension of the "sufficient condition" argument scheme proposed by Walton [Wal96].

Atkinson's Argument Scheme
In the circumstances R
We should perform A
Whose effects will result in state of affairs S
Which will realise a goal G
Which will promote some value V

To avoid confusion with the previous approach, we must first make clear that the notion of value is used here in a different sense. As we shall see, it plays a role comparable to that of a criteria in multi-criteria decision making. Atkinson explains [Atk05] that values should not be confused with goals as "they provide the actual reasons for which an agent wishes to achieve a goal". *Goals* refer to single values, but an action can bring about a *state of affairs* that satisfy many goals, hence affecting different *values*. So, unlike the previous one, this approach explicitly represents both action's consequences, and states actually desired by the agent (preferences). We believe this distinction remains important even if there is no discrepancy between observed and inferred states [BCP06]. Technically, a function *value* maps goals to pairs $\langle v, sign \rangle$ where $v \in V$, and *sign* belongs to the scale $\{+, -, =\}$ (but Modgil [Mod06] adds a notion of degree to which the value is promoted). For instance, using our running example, we could have

$$value(mark \geq 12) = \langle academic\_level, + \rangle$$

meaning that the value (criteria) academic quality is promoted when the mark is over 12.

In this approach, values clearly play the role of criteria. So it looks like specifying goals amounts to specifying a (potentially partial) neutral action. However, the declarative nature of goals allows for more flexible classifications than what we typically have in decision models[1]. For instance, it is possible to easily express that

$$value(age \geq 18 \wedge age \leq 32) = \langle youth, + \rangle$$

[1] Although some approaches try to overcome these limitations, see for instance [aC96]

the value "youth" is only promoted when the *age* falls between 18 and 32. It is also important to note that values are eventually assigned to state of affairs *via* goals. So the justification of value assignment to states is implicitly given by the fact that the goal is reached (or not). One potential problem is that it does not leave any other option if we were to provide some additional justification (for instance related to preference model used). We also refer to [BCP06] for a detailed discussion related to this scheme.

In [ABP05], Amgoud et al. propose an approach explicitly linking argumentation to multi-criteria decision-making. They see an argument as a 4-tuple $\langle S, x, c, g\rangle$ where

- S is the support of the argument,
- x is the conclusion of the argument (the action)
- c is the criterion which is evaluated for x,
- g is the goal and represents the way c is satisfied by x

It is required that S is consistent when we add the fact that the action x has taken place. Here, in a way that is reminiscent of the previous approach, each goal g is explicitly associated to a criterion by means of a propositional formula $g \rightarrow c$, although the possibility of having goals referring to different criteria is also mentioned. In this approach, unlike in [Atk05], the use of (bipolar) scale is explicitly mentioned: the goals will fall either on the negative or on the positive side. Their approach also allows for quantitative measure of how good are the attained goals. So for instance, we may specify that knowledge base has several strata

$$G_2^+ = \{mark \geq 16\};\ G_1^+ = \{16 > mark \geq 12\};\ G_1^- = \{mark < 12\}$$

which means that the marks are considered as "good" from 12, and even "very good" from 16, while it is unsufficient when it is below 12. This comes together with formulae of the form

$$mark \geq 16 \rightarrow academic\_level$$

which explicitly states that the goal G_2^+ affects the criteria "academic level". Now each decision will have some consequences, that will in turn fulfill some goals or not. It is then possible to identify arguments pro and cons a given decision x, by simply scanning the knowledge base and checking which positive (resp. negative) goals are satisfied by the occurrence of a given decision x.

In a very recent proposal, Morge and Mancarella [MM07] propose a multi-attribute argumentation framework for opinion explanation. Here, a main goal is split into sub-goals and so on. They make a distinction between *high level goals* ("abstract goals that reveal the user's need"), and *low-level goals* ("criteria for evaluating different alternatives"). As for the satisfaction of a goal by a given decision, this is explicitly stated by:

- *decision rules* of the form $R : g \leftarrow D, B_1, \ldots, B_n$ meaning that the goal g *can* be achieved by decision D, given that conditions $B_1, \ldots, B_n$ are satisfied.
- *goal rules* of the form $R : g \leftarrow g_1, \ldots, g_n$ meaning that the head of the rule is reached if the goals listed in the body are reached

The notion of priority between rules allows to refine decision rules, in order to make more complex aggregation. So for instance; if we were to specify that we would chose an alternative if it meets one out of two goals, we would specify that

$$R_0 : g_0 \leftarrow g_1, g_2$$
$$R_1 : g_0 \leftarrow g_1$$
$$R_2 : g_0 \leftarrow g_2$$

together with the preferential information that $R_0 \succeq \{R_1, R_2\}$

Now if we inspect what plays the role of a criteria in this approach, it is difficult to say. In fact, there is no notion properly corresponding to that of a criteria: there is no point of view against it is possible to compare alternatives. It would be tempting to say that there exists an implicit preference model stating that the decision-maker prefers to satisfy goals, rather than not. However it is deceptive. It could well be that we have the following preference ordering between rules:

$$R_0 : g_0 \leftarrow g_1, g_2$$
$$R_1 : g_0 \leftarrow \neg g_1$$
$$R_2 : g_0 \leftarrow \neg g_2$$

again with $R_0 \succeq \{R_1, R_2\}$

In that case, it is clearly not possible to evaluate on a single point of view. It is only possible to say that we would prefer an action satisfying *both* g_1 and g_2, rather than only $\neg g_1$ or g_2. Only when the set of rules exhibits a very specific structure is it possible to interpret goals as proper criteria. In general however, this approach is more expressive and cater for preference models where "coalitions" of criteria are considered, which makes the comparison more difficult.

2.3 Discussion

In the previous section we have discussed several approaches to argument-based decision-making. What we have seen is that each approach is rather marginally different from the other ones, but that, by making explicit different steps of the process, they focus on different aspects of the process. Fox and Parsons are the only ones to explicitly represent the justification of a value assignment, however, they do not fully explore this avenue; and hardwire the possibility of having different criteria. Atkinson makes this latter distinction clear, but on the other hand, do not cater for an explicit representation of all the justifications of the value assignment (this only rely on the logical satisfaction: a goal is reached or not, which justifies the value assignment). In this case, it is not possible to represent or indeed challenge the preference structures used. Amgoud *et al.* also rely on the logical satisfaction of goals to justify the value assignment, but the goals are ordered in a way that indeed allows to refine the preference structure, to express various degrees of satisfaction of a goal. Still, this is directly encoded in the knowledge base and cannot be discussed in the process. Also, by using a bipolar scale, they constrain the syntax of goals and prevent themselves from using the full expressivity provided by the logic. Overall, it is important to emphasize that the definition of the argument scheme is of primary importance: by expliciting the inference steps of an argument, we also define what counts as valid "critical question", that is how arguments will interact with each others (how they can be attacked and so on).

There are, on the other hand, many similarities between these approaches. First, the evaluation is made possible by an explicit representation of the consequences of the action. By relying on logic to represent these states of affairs, it is more expressive than the ordered scale that is usually used in decision models. One further possibility that is offered by this representation is that profile may be only partially defined, whereas in decision models you would require each action to be evaluated on each different criteria.

The third, perhaps most striking similarity, is that they all rely on a method of *intrinsic evaluation*, and use more or less explicitly a neutral action. In decision models, on the other hand, the canonical case is the *pairwise evaluation*, that is, actions are evaluated against each others, and not against a neutral action. Although the use of neutral action can be justified, it has some consequences and drawbacks that, we feel, is important to emphasize:

- the adoption of a neutral action makes very important the definition of each *neutral point*, that is, the frontier (or more generally zone). In particular, a seemingly insignificant modification of the frontier can have tremendous consequences (as we shall see in the next section).
- in the context of multiparty decision-making, the problem is made even more thorny because it also generates potential conflicts as to what should count as positive or negative arguments, when agents would maybe more easily come up with an agreement if two alternatives were compared.

To elaborate on the point mentioned above, we refer to a recent discussion on the UAI (Uncertainty in Artificial Intelligence) list where the problem of "where to draw the line" emerged as a thread of discussion. A very illustrative real example of this problem was given, as reported here:

> The contested 2000 US Presidential election and the question of "hanging chads." [...] in many instances the perforation was partial – leaving a hanging chad, a scrap of paper hanging from the voting card. So how was one to decide whether or not a partial perforation was or was not a vote for the position or person next to the perforation? One method,

> sometimes used, was to have the vote counter ask, "What intent does this perforation indicate?" Another approach was possible: It is useless or impossible to try to determine or guess the voter's intention. One must instead ask whether this perforation looks more like a vote than a non-vote [2]."

So for instance two agents could discuss whether a given value should count as a positive goal or a negative argument, one arguing that this is not high enough a mark to be counted as a positive argument... while, it would be more practical to simply ask the agents to simply say whether they prefer an alternative versus another wrt. this given criterion.

3 Aggregation

Once you have decided what counts as arguments pro and con, for each possible decision, it is necessary to aggregate them to eventually decide what alternative to select. At this point, there is an important question to be asked: how is it that you handle potential interactions between arguments that refer to different criteria?

– if you assume that these interactions do not exist, or do not take them into account, then you might first aggregate arguments independently on each criterion, and then aggregate the resulting criteria using a given operator;
– if you take into account these interactions, then it is necessary to design an aggregation process that will aggregate arguments labelled by criteria.

There are many rational ways to aggregate sets of pro and cons. Bonnefon and Fargier [BF06] offer a nice overview of different possible approaches. These approaches take into account the fact that the arguments are bipolar and qualitative. The importance of arguments is described on totally ordered scale of magnitude. In order to compare these qualitative, bipolar sets, they present several procedures: the *Pareto comparison* (sets of arguments are compared as a problem of bi-criteria decision), the *implication rule* (this rule focuses on the most important arguments in the situation), the *cardinality rules* (based on a levelwise comparison by cardinality), and so on. The characterization of these rules was introduced in [DF05], and [BF06] present an extensive empirical assessment of the descriptive validity of these rules. What Amgoud *et al.* show in [ABP05] is that it is possible to retrieve various classical aggregation operators in their framework. They propose to compare decision in terms of positive and negative arguments (using a complex scheme for evaluating the strength of argument, which depends on three parameters : the *certainty level*, the *importance degree of the criterion*, and the *(dis)satisfaction degree of the criterion*). Two principles based on preference relation between the arguments are proposed : promotion focus (take into account only the supporting arguments) and preventing focus (considers only the arguments against decisions). They show that the presented

[2] [P. Tiller, post on UAI list in response to L. Zadeh]

framework captures different multiple criteria decision rules to select the best decision. The rule for the choice is characterized by the fact that the criteria have or not the same importance level. In this approach however, the potential interaction between arguments, as analysed in the seminal work of Dung [Dun95], is not considered. To the best of our knowledge, the *value-based argumentation* framework of [BC02] is the only approach so far that proposes to compute the acceptable arguments from a set of labelled arguments. Indeed, an argument refers to a given criterion (or “value” in the sense previously mentioned in the work of Atkinson [Atk05]). Argument systems, in the sense of Dung [Dun95], hence record interaction between arguments, possibly related to different values. *Audiences* are different ways to order those values. It is then possible to identify those arguments that will be accepted regardless of the chosen audience (*objectively* acceptable), while some others arguments can only be *subjectively* acceptable. In this case, the interaction between arguments pertaining to different criteria is fully recognized. The aggregation of values remains rather limited though, for it is only possible to order the values to reflect their degree of importance. So for instance it would not be possible to use an aggregation operator like the majority.

We conclude by a further remark related to the choice of the method of evaluation (intrinsic or pairwise). Both techniques may provide different, even contradictory, results, depending on the choice of the profile. Consider the following example. We assume that each criteria on an evaluation scale form 0 to 9. We take the neutral action to be $p = [5, 5, 5]$, meaning that the neutral point on each criteria is 5, and consider the following performance table :

	g_1	g_2	g_3
a	8	6	8
b	7	4	2
c	9	7	4

We will now use the following notation: $c \succ p$ *since* $[+, +, -]$, to specify that c is preferred to p because a strict majority of arguments (two arguments out of three) supports this proposition (only the last criteria disagrees with this). We will now compare the results obtained by aggregation, comparing the cases where an intrinsic or pairwise evaluation is used.

- in the case of intrinsic evaluation, we get $a \succ p$ *since* $[+, +, +]$ and $c \succ p$ *since* $[+, +, -]$. The obtained set of argument for a dominates that obtained for c: any rational aggregation method will give the outcome that $a \succ c$.
- in the case of a pairwise comparison (we don’t need to use the neutral action then), we have on the other hand $c \succ a$ *since* $[+, +, -]$, hence $c \succ a$

This simply illustrates that both methods may return contradictory results, which is easily explained by the fact that the categorisation as argument pro or con may make the preference model rather coarse-grained (of course, we do not discuss here the possibility of using a more detailed bipolar scale, as mentionned earlier in this paper).

4 Conclusion

The primary aim of this paper was to offer a critical review of existing approaches adopting an argumentative stance towards decision-making, adopting the viewpoint of (multicriteria) decision theory. We emphasized in particular that arguments pro or against a given action are generally regarded as resulting from a comparison against a neutral action (drawn from the agent's preferences). This intrinsic evaluation technique departs from the pairwise evaluation, and raises some difficulties it is good to be aware of. On the other hand, it appears that these approaches seem to have much to offer to decision models, because they allow a great expressivity in the specification of agents' (possibly partial) preferences, and because they make explicit many aspects that are usually somewhat hidden in decision models. At the level of aggregation, despite recent progresses, the question of how the multicriteria feature should be taken into account when it comes to aggregating several arguments (that may potentially interact and refer to different criteria) remains largely unexplored.

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