Qualitative evaluation of decisions in an argumentative manner – A general discussion in a unified setting

Henri Prade
IRIT Université Paul Sabatier,
118 route de Narbonne,
31062 Toulouse cedex 4, France
prade@irit.fr

Abstract

The paper intends to provide a unified discussion of different types of decision processes (decision under uncertainty, multiple-criteria decision, case-based decision, rule-based decision) from an argumentation point of view. This means here that in the evaluation of a decision, we carefully distinguish what positively contributes to its evaluation and what negatively contributes to it. The discussion favors a qualitative evaluation setting, which uses a bivariate scale for assessing the values of consequences. The nature of arguments changes with the type of decision, as well as how their strength can be assessed. However, a preliminary view of how balancing pros and cons for ranking decisions is proposed. Some illustrative examples are provided.

1 Introduction

Choosing among a set of possible decisions is often in practice a matter of balancing arguments pro (in favor of) and cons (against) the different possible choices. Such a view of decision is old and has been already emphasized by Benjamin Franklin [Franklin, 1772]. Interestingly enough, the notion of argument is not one of the key concepts in the formal approaches to decision making. Still, from an artificial intelligence (AI) point of view, the capability of explaining the choices proposed by a decision-support system to an end-user matters. Then, decision-making is no longer only a matter of computing an optimal decision in agreement with rationality postulates on the basis of numerical utility and uncertainty distribution functions. In some applications, it is important not only to suggest the best choice(s) to a user, but also the reasons of this recommendation should be provided in an understandable format. This amounts to provide "strong" arguments in favor of the proposed choice.

Argumentation has been thoroughly studied in the recent years in AI (e.g. [Amgoud and Cayrol, 2002]; [Chesnevar, *et al.*, 2000], [Dung, 1995], [Fox and Parsons, 1997]), from an inference point of view for reasoning in face of inconsistent knowledge. In these approaches, arguments are built, then the most acceptable ones (which are not defeated by rebuttal or under-cuttings) are selected, and finally plausible conclusions are drawn from them.

Recently, an argumentation-based approach to qualitative decision under uncertainty has been proposed [Amgoud and Prade, 2004]. In this approach, a plausibility distribution on the different possible states of the considered world can be computed from a layered knowledge base, while a qualitative value function can be computed from a set of goals associated with priority levels. The approach favors decisions for which there exists strong arguments supporting them (pessimistic attitude), or for which there does not exist strong arguments attacking them (optimistic attitude), taking into account the available knowledge on the one hand, and the goals pursued by the decision maker on the other hand. [Amgoud *et al.*, 2005] have also contributed an introductory discussion of what may be the role of argumentation in multiple criteria decision, and provided an illustration in the case of the flexible querying of a database. Then, criteria functions are viewed as providing arguments in favor or against a choice, depending if the criteria are well or poorly satisfied. Argumentation can be also relevant in other types of decision processes, such as case-based decision, or rule-based decision. The paper intends to provide a general discussion of these various forms of decision in terms of arguments, emphasizing what is common and what is different in each case. Since argumentation is qualitative in nature, qualitative decision models are privileged. The paper is organized as follows. Section 2 provides a general setting for decision problems and introduces the notations. Sections 3, 4, 5 and 6 successively consider decision under uncertainty, multiple-criteria decision, case-based decision, and rule-based decision, each time with an argumentative point of view.

2 Decision problems

Let $D = \{d_1, \ldots, d_n\}$ be a set of possible decisions. In decision under uncertainty, a decision d is viewed as a mapping from a set of states $S = \{s_1, \ldots, s_m\}$ to a set of consequences $X = \{x_1, \ldots, x_t\}$. When the available information about the state of the world is imprecise or uncertain, the decision maker does not know precisely and with complete certainty in what state (s)he is, and thus may be unsure about the consequences of any decision in D. It is assumed here that uncertainty is modeled by a complete pre-order, encoded by a possibility distribution π; for each $s \in S$, $\pi(s)$ assesses the plausibility level to be in state s. $\pi(s)$ is supposed here to belong to a finite linearly ordered univariate scale U with top element denoted **1** and bottom element **0**, by convention. The closer to **0** $\pi(s)$, the less plausible s; in particular $\pi(s) = \mathbf{0}$ means that s is impossible, but there may exist distinct states s and s' such that $\pi(s) = \pi(s') = \mathbf{1}$. π is assumed to be normalized, i.e., $\exists s_0, \pi(s_0) = \mathbf{1}$.

Each consequence x can be evaluated using a set of criterion functions $C = \{c_1, \ldots, c_p\}$, giving birth to an evaluation vector $(c_1(x), \ldots, c_p(x))$. For simplicity, we shall assume that $\forall j\ c_j(x) \in L$, where L is a common scale where the value of any x according to each criterion c_j can be assessed. This means that each function c_j is of the form $c_j = v_j \circ f_j$ where $f_j(x)$ is the estimate of x according to criterion j (e.g. the cost of x) and $v_j(y)$ evaluates how good or bad is the estimate $y = f_j(x)$. In order to remain in a qualitative setting, L is assumed to be finite; moreover, in order to introduce a clear distinction between good and bad consequences, a symmetrical bivariate scale will be used. $L = L^+ \cup L^-$, with $L^+ = \{0, +1, +2, \ldots, +n\}$ and $L^- = \{-n, \ldots, -2, -1, 0\}$, where the elements of L^+ and L^- are listed increasingly, and +k (resp. −k) is just a convenient notation for denoting the k^{th} positive (resp. negative) level in the scale, and 0 is the neutral level. The larger +k (resp. the smaller −k), the best (resp. the worst) the evaluation (however +k and −k have not necessarily all the properties of integers).

A repertory $\mathcal{R}$ of decision cases is a set of triples of the form (s_i, d_j, x_k) understood as "d_j has been applied in situation s_i with result x_k." The set of states is supposed to be equipped with a similarity relation Sim (assumed to be at least reflexive and symmetrical). Then $\mathrm{Sim}(s_i, s)$, which evaluates the closeness of states s_i and s, can be the basis for recommending a decision d in state s, depending on the similarity with states s_i where d was already positively experienced. It is also assumed that $\mathrm{Sim}(s_i, s_j)$ belongs to a finite linearly ordered univariate scale V. A decision rule is of the form "if $s \in T$ then d is recommended", and means that if you are in situation which is in T, it is advisable to apply d. Clearly, the rule is especially reasonable if $\forall s \in T$, d(s) is a consequence that receives good evaluations. In fact, different forms of decision rules exist, as explained later.

Clearly, all the above-mentioned features, uncertainty, multiple criteria, existence of reference cases, or use of advisory rules, are not usually considered together in decision problems, even if in day-life decisions, all of them may be present, and can be involved in arguments. What can be an argument for (resp. against) a decision? It should be a piece of information that supports (resp. challenges) the decision from the point of view of its expected consequences. In the following, we make more precise this informal definition in the case of each considered type of decision, discussing how to compare them, and to base the a decision on them.

3 Decision under uncertainty

[Dubois *et al.*, 1999] have provided axiomatic justifications for a pessimistic and an optimistic qualitative decision index, respectively computed as

$$E_*(d) = \min_{s \in S} \max(c(d(s)), r(\pi(s))) \quad \text{and}$$
$$E^*(d) = \max_{s \in S} \min(c(d(s)), m(\pi(s))).$$

where r is a decreasing map from U to L such that $r(\mathbf{0}) = +n$ and $r(\mathbf{1}) = -n$ and m is an increasing map from U to L such that $m(\mathbf{0}) = -n$ and $m(\mathbf{1}) = +n$. $E_*(d)$ (resp. $E^*(d)$) is all the greater as *all* the plausible states s according to π lead (resp. *there exists* a plausible state s that leads), when d takes place, to a consequence that is among the most preferred ones according to a criterion function c. $E_*(d)$ is small as soon as there exists a possible consequence of d which is both highly plausible and whose satisfaction is poor with respect to c. The condition $m(u) > 0 \Leftrightarrow r(u) < 0$ is required for maintaining the duality between $E_*(d)$ and $E^*(d)$. However, neither this view, nor its argumentation-oriented counterpart [Amgoud Prade, 2004] takes advantage of the fact that L may be a bivariate scale.

Let $c^+(x) = c(x)$ if $c(x) \geq 0$ and $c^+(x) = 0$ if $c(x) \leq 0$, and $c^-(x) = 0$ if $c(x) \geq 0$ and $c^-(x) = -c(x)$ if $c(x) \leq 0$ (where $-(-k) = +k$) be the restrictions of c to its positive part and the absolute value of its negative part respectively. Denoting $E_*(d; c^+)$ and $E^*(d; c^-)$ the results of substituting c^+ and c^- to c in $E_*(d)$ and in $E^*(d)$ respectively, one can define a refined decision index, distinguishing between

- really good decisions such that $E_*(d; c^+) > 0$ (and then $E^*(d; c^+) > 0$ and $E^*(d; c^-) = 0$)
- really bad decisions such that $E_*(d; c^-) > 0$ (and then $E^*(d; c^-) > 0$ and $E^*(d; c^+) = 0$)
- decisions having pros and cons such that $$E^*(d; c^+) > 0 \text{ and } E^*(d; c^-) > 0$$ (and then $E_*(d; c^+) = 0$ and $E_*(d; c^-) = 0$)
- "neutral" decisions such that $$E_*(d; c^+) = 0 \text{ and } E_*(d; c^-) = 0.$$

The above expressions of $E_*(d)$ and $E^*(d)$ show that decisions are evaluated on the basis of the comparison of states s both evaluated in terms of their plausibility $\pi(s)$ and how satisfactory they are when decision d takes place (c(d(s))). However, the two evaluations are combined for each s, and then aggregated for all states in the two decision criteria. We now discuss how the plausibility and satisfaction levels are weighting the arguments pro and cons a decision. Let $S^* = \{s, \pi(s) > \mathbf{0}\}$ be the set of the states that are somewhat plausible. Clearly, the utility function c, for a considered decision d, induces the two sets of states $Pro(d) = \{s, s \in S^*, c(d(s)) > 0\}$ and $Cons(d) = \{s, s \in S^*, c(d(s)) < 0\}$, corresponding to the states for which d leads to a strictly positive consequence and those for which a strictly negative consequence is reached. Thus, Pro(d) (resp. Cons(d)) represents the basis for the arguments in favor (resp. against) decision d. The "arguments" s in Pro(d) and Cons(d) are both associated with a satisfaction level c(d(s)) and a plausibility level $\pi(s)$. They are aggregated in $E_*(d)$ and $E^*(d)$; however, we keep them separate in the following discussion, for avoiding a commensurateness requirement of the uncertainty and preference scales. Then the evaluations of each possible state s as an argument in favor of / against d is

$$ePro(d) = \{(c(d(s)), \pi(s)), s \in S^*\ c(d(s)) > 0\}$$
$$eCons(d) = \{(c(d(s)), \pi(s)), s \in S^*\ c(d(s)) < 0\}.$$

Arguments can be built from possibilistic propositional bases K and G encoding uncertain pieces of knowledge and prioritized goals respectively, which are the syntactic counterparts of distribution π and the value function c. Let us take an example to show how Pro(d) and Cons(d) can be derived from K and G.

Example 1. It is about taking an umbrella (um) or not (¬um), knowing that the sky is cloudy (cl). The knowledge base is $K = \{(\neg um \vee \neg we, \mathbf{1}), (\neg ra \vee um \vee we, \mathbf{1}), (cl, \mathbf{1}), (ra \vee \neg we, \mathbf{1}), (\neg cl \vee ra, \lambda)\}$ with $\mathbf{0} < \lambda < \mathbf{1}$, and *ra* means 'it rains', *we*: 'being wet'. The associated possibility distribution (e.g., [Benferhat *et al*., 1992]) is

$\pi_K(cl \wedge um \wedge ra \wedge \neg we) = \pi_K(cl \wedge \neg um \wedge ra \wedge we) = \mathbf{1}$, $\pi_K(cl \wedge um \wedge \neg ra \wedge \neg we) = \pi_K(cl \wedge \neg um \wedge \neg ra \wedge \neg we) = r(\lambda)$ and π_K is $\mathbf{0}$ otherwise; in particular $\pi_K(we \wedge um) = \mathbf{0}$.

The stratified preference base $G = \{(\neg we, +n), (\neg um, +k)\}$ with $0 < +k < +n$ expresses that one does not like to be loaded with an umbrella, but it is more important to be dry. The set of allowable decisions is D = {um, ¬um}, i.e., taking an umbrella or not. We have for c restricted to the states s that are somewhat possible ($\pi_K(s) > \mathbf{0}$)

$c(cl \wedge \neg ra \wedge um \wedge \neg we) = -k$; $c(cl \wedge ra \wedge um \wedge \neg we) = -k$;
$c(cl \wedge \neg ra \wedge \neg um \wedge \neg we) = +n$; $c(cl \wedge ra \wedge \neg um \wedge we) = -n$.

Thus, $Pro(um) = \{\emptyset\}$;
$Cons(um) = \{cl \wedge ra \wedge um \wedge \neg we, cl \wedge \neg ra \wedge um \wedge \neg we\}$;
$Pro(\neg um) = \{cl \wedge \neg ra \wedge \neg um \wedge \neg we\}$;
$Cons(\neg um) = \{cl \wedge ra \wedge \neg um \wedge we\}$.

In this example, if we are pessimistic and only negative "arguments" are considered, namely Cons(um) and Cons(¬um), the best decision is to take the umbrella since

$\min\{c(s), s \in Cons(um)\} > \max\{c(s), s \in Cons(\neg um)\}$.

Indeed, consequences can be worst (being wet) when not taking the umbrella than when taking it (being loaded). If we are optimistic and focusing only on positive arguments, then the best decision is not to take the umbrella, since

$\max\{c(s), s \in Pro(um)\} < \min\{c(s), s \in Pro(\neg um)\}$.

However, one may consider that the plausibility of being in Pro(¬um) is quite low (it is equal to $r(\lambda)$), while the plausibility of being in Cons(¬um) is much higher, which may lead to hesitate (as captured by $E^*(d)$, in case of a low certainty of rain w.r. t. the satisfaction of being unloaded).

The construction of arguments stated under the form of logical expressions is beyond the scope of this paper. See [Amgoud, Prade, 2004] for details.

Example 2. The following example is taken from ASPIC project (www.argumentation.org). It does not involve any explicit uncertainty. One has to *prevent_blood_clotting* for a patient. One has some pieces of medical knowledge encoded as rules:

administer_asprin → prevent_blood_clotting
administer_chlopidogrel → prevent_blood_clotting
administer_asprin → gastric acidity
administer_asprin → efficiency
administer_chlopidogrel → reduced_efficiency

Also, reduced_efficiency is subsumed by efficiency

efficiency → reduced_efficiency

This constitutes the available knowledge K (where words are abbreviated by their initials). $K = \{aa \to pbc, ac \to pbc, aa \to a, aa \to e, ac \to re, e \to re\}$.

Besides, the set G of prioritized goals is here $G = \{(pbc, iii), (\neg a, i), (re, iii), (e, ii)\}$, where iii, ii and i denote priority levels with iii > ii > i. (re, iii) means that it is imperative to have at least a reduced efficiency, and the (full) efficiency goal (e, ii) has a smaller priority. Potential decisions are *D={aa, ac}*

In such a case, Pro(d) (resp.Cons(d)) can be directly expressed in terms of the weighted set of goals that are reached (resp. missed) when decision d takes place. It can be checked that if *ac* is chosen it cannot be proved that goal *(e, ii)* is fulfilled, while if *aa* is chosen only the less prioritized goal *(¬a*, i) is missed. So one is led to choose *aa*.

Later, it is learnt that the patient has a history of gastritis (hg). Since asprin causes acidity, it will lead to gastrointestinal irritation (gi). Then K is completed into *K ∪ {hg, hg ∧ a → gi}*, and a goal is added in G, namely *G = G ∪ { (¬gi, iii)}*. Now *ac* is preferred to *aa* since choosing *aa* contradicts the satisfaction of the new very important goal *(¬gi, iii)*, while with *ac* only the relatively less important goal *(e, ii)* is missed (even if not fully satisfactory). Finally, a new action option, *administer_asprin* with another action *administer_protein_pump_ inhibitor* (*appi*), is considered since *appi* reduces the acidity resulting from asprin. Thus K becomes *K ∪ {aa ∧ appi → ¬a}*, and a new decision is added, namely *D* becomes *D ∪ {appi}*. When new information is added to a knowledge base, then different forms of inconsistency can take place. Here the rules *aa → a and aa ∧ appi → ¬a* clearly conflict. This is a standard situation of non-monotonic reasoning with rules of different levels of specificity and with potential exceptions that can be properly handled by stratifying K (see [Benferhat *et al.*, 1992]). Then the rule *aa ∧ appi → ¬a* gets a priority higher than the one of *aa → a*. Then it can be checked that now the best decision is *aa ∧ appi*, which secures the satisfaction of all goals in G whatever their priority.

4 Multiple criteria decision

Multiple-criteria decision making is somewhat similar to decision under uncertainty replacing the states by criteria ; see [Dubois et al. 2000] for a discussion. In multi-criteria decision-making, arguments are based on the values of criteria used for evaluating each possible choice. Thus, the decision should be made, and should be explainable, on the basis of two subsets Pro(d) and Cons(d), which respectively gather the arguments in favor and against a possible choice d. Here

Pro(d) = $\{c_i, c_i(d) > 0\}$; Cons(d) = $\{c_i, c_i(d) < 0\}$.

Thus, if we use, the scale [0,1], the closer to 1 the value of criterion i for choice X is, the stronger the value of i is an argument in favor of X; the closer to 0 the value of criterion i for choice X is, the stronger the value of i is an argument against X.

Example 3 (Choosing a prescription). Imagine we have 4 criteria:1. availability; 2. reasonableness of the price; 3. efficiency; 4. acceptability.

Assume they are all valued on the scale {−2, −1, 0, +1, +2}. Suppose one has for instance three alternatives, d, d' and d", respectively valued by vectors e(d) = (−1, +1, +2, 0), e(d') = (+1,−1, +1, +1), and e(d") = (+2,−1, +2, −2), where the *ith* component of the vector corresponds to the value of the *ith* criterion.

How to compare such vectors? One can think of two types of approaches: separate handling, or not, of the positively-valued and negatively-valued criteria. Assume for the moment *equal importance* of criteria.

- i) uniform handling of positive and negative values: This corresponds to the usual multiple-criteria approach. On may use the leximin approach, which amounts i) to increasingly re-ordered the components of the vectors; ii) to ignore the smallest values when they are identical, and iii) to determine the ordering on the basis of the smallest discriminating values. This refines the conjunctive aggregation based on minimum. Using leximin on the example yields d" < d < d' since (−2,−1, +2, +2) < (−1, 0, +1, +2) < (−1,+1, +1, +1).
- ii) separate handling of the positively-valued and negatively-valued criteria. Let us introduce in Pro and Cons the values of the criteria. We have

Pro(d) = $\{c_2(d) = +1, c_3(d) = +2\}$;
Cons(d) = $\{c_1(d) = -1\}$.
Pro(d') = $\{c_1(d) = +1, c_3(d) = +1, c_4(d) = +1\}$;
Cons(d') = $\{c_2(d)) = -1\}$
Pro(d") = $\{c_1(d) = +2, c_3(d) = +2\}$;
Cons(d") = $\{c_2(d) = -1, c_4(d) = -2\}$.

Then, one may compare possible choices according to their advantages and disadvantages respectively. This requires the comparisons of pairs of sub-vectors, which may be of different lengths, and which are both positive, or both negative. One may also compare and combine the positive and negative strengths concerning the same possible choice. This again amounts to compare pairs of sub-vectors, one positive with one negative. In both case, especially on discrete scales, one may use what may be called "Franklin' principle": namely, a positive argument of a given strength neutralizes a negative argument of the same strength, i.e. here +1 & −1 = 0 ; + 2 & −2 = 0. In our example, we have,

Pro(d") ≥ Pro(d) and Cons(d") ≥ ConsC(d).

Two conflicting statements! However,

Pro(d) & Cons(d) = {+2}; Pro(d') & Cons(d') = {+1, +1}; Pro(d") & Cons(d") = {+2, −1}

Let us define a Pareto-consistent ordering among subsets of scale values, e. g.

{+2, +2} > {+2, +1} > {+1, +1} > {+2} > {+1} > {+2, −1} > ∅ = {+1, −1} > …

This enables us to rank-order the possible choices. Here, it yields d" < d < d' again.

Assume now the *unequal importance* of the criteria. An argumentation system should balance the levels of satisfaction of the criteria with their relative importance. Indeed, for instance, a criterion i highly satisfied by X is not a strong argument in favor of X if i has little importance. In the case where all the criteria have not the same importance, several approaches can be considered depending on the way importance is assessed.

- i) weighted min aggregation can be used if each criterion *i* has a given importance level $\square_i$, such that max $\square_i$ = **1** where **1** is the top element in the importance scale U; it corresponds to an evaluation e(d) of the form $e(d) = \min_i \max(c_i(d), r(\square_i))$ where r is the order-reversing map of the common scale used for assessing the evaluations of all the criteria and their importance levels (commensurateness hypothesis). For $\square_i$ = **1** for all the criteria, the min aggregation is recovered.
- ii) Only an importance ordering is available among criteria. This can be handled by applying the following principle: i) consider the subset of criteria that are the most important ; ii) apply one of the above procedures to them ; in case of ties consider the second subset of criteria w. r. t. to importance ordering and repeat the procedure. See the general framework discussed in [Dubois *et al*., 2003] for other possibilities.

Logical expression of dependent criteria and goals. Evaluations of possible choices are sometimes expressed in terms of goals to be reached, rather directly in terms of criteria. The goals are then expressed in terms of constraints, which maybe prioritized, that should be satisfied by possible choices. For instance,
$G = \{c_1(d) \geq +1, c_3(d) \geq 0, (c_2(d) = +2) \quad (c_4(d) \geq +1)\}$.
Goals can be more generally defined in terms of conjunctions and disjunctions of more elementary requirements, weighted in terms of importance. Then Pro(d), Cons(d) should be now defined directly in terms of goals in G, which are satisfied or which are missed. Moreover, there may exist known dependencies between criteria values. This gives birth to another knowledge base. For instance,
$D = \{c_3(d) = +2 \,\square\, c_2(d) \leq \square 1, c_1(d) \geq + \,\square\, c_2(d) \geq +\}$.

Then one can determine what goals are superceded by others, what goals are impossible to reach. Then a question is raised: in case of redundancy between two goals, are (dis)satisfaction to be counted one time or two times? Note that if one counts two times two logically equivalent goals, it is a way to give them more importance. In case of mutual exclusiveness between two goals, then automatically one is counted positively and the other negatively; should it be counted in the same way as the two goals were independent?

5 Case-based decision

In case-based decision [Gilboa and Schmeidler, 1995], decision is based on past experience stored under the form of a repertory R of past cases $j_d = (s_j ; d; u_j(d))$ describing that in situation s_j a specified action d has led to consequences whose value is assessed by $u_j(d)$. Now consider a current situation s_0. Then a similar situation s_j encountered in the past, where some action d has/have been experienced positively, supports this action d as a good candidate for the current situation. Let $Sim(s_0; s_j) \,\square\, [0,1]$ be the degree of similarity between s_0 and s_j.

In this perspective, examples and counter-examples can now be considered as arguments in favor or against an action d. Indeed, the case of an action d which has highly succeeded in a situation very similar to the current situation is an argument in favor of choosing d in the current situation. On the contrary, the case of an action d which has highly failed in a situation very similar to the current situation is a strong argument against the choice of d. When the similarity is weaker, the arguments become weaker (less relevant).

Assume the u_j's for all j take their values on a bipolar univariate scale with neutral point 0. Then let $Examples(d) = \{Ex_1(d), \ldots, Ex_m(d)\} = \{j_d \,\square\, R \mid u_j(d) > 0\}$ and $Counter\text{-}Examples(d) = \{C\text{-}Ex_1(d), \ldots, C\text{-}Ex_n(d))\} = \{j_d \,\square\, R \mid u_j(d) < 0\}$ be the sets of examples and counter-examples associated with a candidate action d. Then the arguments pro and cons associated with d in situation s_0 are
$Pro(d) = \{Ex_i(d) \mid Sim(s(Ex_i(d)), s_0) > 0 \text{ for } i=1,m\}$
$Cons(d)=\{C\text{-}Ex_i(d) \mid Sim(s(C\text{-}Ex_i(d)),s_0) > 0, i=1,n\}$
where Sim takes its value in a unipolar univariate scale with bottom element 0, and $s(Ex_i(d))$ (resp. $s(C\text{-}Ex_i(d))$) returns the situations sj associated with example $Ex_i(d)$ (resp. C- $Ex_i(d)$). The force of an argument pro (resp. cons) d in situation s_0 is the pair $(Sim(s(Ex_i(d)), s_0), u_j(d))$ (resp. $(Sim(s(C\text{-}Ex_i(d)), s_0), u_k(d))$), where the argument pro (resp. cons) is $Ex_i(d) = (s_j, d, u_j(d))$ (resp. $C\text{-}Ex_i(d) = (s_k, d, u_k(d))$). As can be seen, $Sim(. , s_0)$ plays the role of a weight of importance for the arguments.

6 Rule-based decision

Decision-oriented rules are of the form "if <situation> then <decision>". This general format covers a variety of possibilities. The rule may be imperative "if situation A then one should do d", in a positive, or in a negative way ("if situation A then don't do d"), or may express a mere guaranteed possibility "if situation A then you can do d", or a recommendation "if situation A then d is advisable (maybe with some strength)", see, e.g. [Dubois and Koning, 1994]. Here <situation> may be understood as a set of possible states, Indeed, from a collection $\{(s, c(d(s))), s \,\square\, S^*\}$, one can derive rules of the form "if $s \,\square\, A_j$ then do d, with a (guaranteed) satisfaction level w_j" with $w = \min_{s \square A} c(d(s))$, or if "$s \,\square\, A_j$ then don't do d" (because $\square s_0, s_0 \,\square\, Aj$ and $c(d(s_0)) < 0$ with $\square(s)$ high). <situation> may also refer to a set of scores of criteria: for example, "if $c_i(d(s)) < l$ or $c_k(d(s)) < r$, don't do d".

A set of rules of the form "if $s \in A_j$ then do d_j" (where the A_j's cover S) is in general insufficient for making a decision in incomplete information situations A such that A overlaps several A_j's without being included in one of them. It is why the set of decision rules may include default rules that states general pieces of advise, together with more specific rules; then a non-monotonic reasoning machinery is required to properly use the set of rules. In order to cope with the possible lack of coverage of the set of rules, a fuzzy rule-based interpolation mechanism (quite similar to case-based decision as described above) may be used, which relies on the similarity between the current situation and the classes of situations appearing in the condition parts of the rules. This presupposes some continuity in the decision processes, while non-monotonic reasoning, on the contrary, acknowledges the fact that some specific features may turn a normal instance in a class of situations in one with a different behavior.

In case we have at our disposal two sets of rules, specifying on the one hand that "if situation A_j then don't do d_j", and on the other hand that "if situation A_j then you can do d_j", we are in a bipolar situation that gives naturally birth to arguments in favor of a decision d (namely the set of rules $Pro(s_0,d)$ that apply in the current situation s_0 and support it), and arguments against d (namely the set of $Cons(s_0,d)$ rules that apply and cancel its possible use). In such an approach d is eligible if d □ $Pro(s_0,d)$ and d □ $Cons(s_0,d)$. In case of weighted rules, this eligibility condition becomes graded.

7 Concluding remarks

This paper has provided a preliminary discussion of the idea of argumentation-based decision in different settings, raising issues through illustrative examples. The strengths of arguments in favor of, or against, a considered decision may be assessed in different manners, raising the problem of their comparison in a qualitative way. This should lead to a systematic study of these issues.

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