Legal Knowledge and Information Systems
A. Wyner and G. Casini (Eds.)

doi:10.3233/978-1-61499-838-9-27

Dimensions and Values for Legal CBR

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Abstract. We build on two recent attempts to formalise reasoning with dimensions which effectively map dimensions into factors. These enable propositional reasoning, but sometimes a balance between dimensions needs to be struck, and to permit trade offs we need to keep the magnitudes and so reason more geometrically. We discuss dimensions and values, arguing that values can play several distinct roles, both explaining preferences between factors and indicating the purposes of the law.

Keywords. legal case based reasoning, dimensions, factors, values.

1. Introduction

Much work on reasoning with legal cases has been in terms of dimensions, introduced in HYPO [6], and factors, developed from dimensions in CATO [5]. Factors are stereotypical patterns of facts, either present or absent in a case, and, if present, favour either the plaintiff or the defendant. Dimensions, in contrast, are ranges of values (numeric or enumerated), running from an extreme pro-plaintiff point to an extreme pro-defendant point. The applicability of dimensions to a case, and the point at which the case lies, is determined by the case facts, and the dimension may favour either party. Most attention has been focussed on factors and factor based reasoning was formalised by Horty [16] and refined by Rigoni in [20]. A more detailed history of this line of development is given in [9]. More recently it has been argued that factors fail to capture some of the nuances present in legal Case Based Reasoning (CBR), and dimensions are needed to capture the *degree* to which a party is favoured [4] and to bridge from factors to the facts of a case (see[19] and [2]). This revival of interest has led to efforts by both Horty and Rigoni to extend their formalisations of factor based reasoning to dimensions in [15] and [21] respectively. Both Horty and Rigoni reduce dimensions to factors: in this paper will we retain magnitudes for some dimensions.

This paper is a shortened version of [7][1] and will focus on the main contributions of that paper. We represent domain knowledge as an Abstract Dialectical Framework (ADF) [13] as used in [3]. The key points are:

- Any legal CBR problem can be reduced to a series of steps involving at most two dimensions, so that higher dimensional spaces need not be considered;

[1] Available at http://intranet.csc.liv.ac.uk/research/techreports/tr2017/ulcs-17-004.pdf. For more context and detail see [7].

- The non-leaf nodes of the ADF can be seen as being one of five types, as determined by their children. For some nodes dimensions cannot be reduced to factors and need to retain their magnitude, to permit trade offs;
- Values are required to play several different roles, not just the expression of preferences.

After a summary of [15] and [21], we discuss each of these points in turn.

2. Formalising Factors and Dimensions

The formalisations of factor-based reasoning of both Horty and Rigoni are based on the method of expressing precedents as rules found in [18]. A case is considered to be a triple $\langle P, D, o \rangle$, where P is the set of all pro-plaintiff factors present in the case, D is the set of all pro-defendant factors present in the case and o is the outcome, either plaintiff (π) or defendant (δ). Now $P \rightarrow \pi$ will be the strongest reason to find for the plaintiff and $D \rightarrow \delta$ will be the strongest reason the find for the defendant. We can therefore deduce that either $P \succ D$ or $D \succ P$ depending on the value of o. A key insight of Horty is that $P \rightarrow \pi$ may be stronger than is required and some subset of P may be sufficient to defeat D. The use of P gives rise to what Horty terms the *rule* or *result* model and the subset the *reason* model.

In [15] Horty uses precedents to map a dimension into a factor. The point at which the factor becomes present depends on the facts of the case (result model) or the tests given in the opinion (reason model), as determined by the available precedents. However, as Horty shows, on this account the result and reason models collapse and the reason does not provide an effective constraint on subsequent decisions. Rigoni objects to these points and in [21] he avoids both of them by mapping a dimension into several factors similar to [19], with a point (the switching point (SP)) determined by the preferences at which the factors cease to favour one side and begin to favour the other. SP may lie on, or between, factors. Now reasons may be weaker than results in two ways: either they may contain fewer factors as in [15], or they may contain weaker factors from the same dimension. Rigoni also reconises that not all aspects of a case will contain magnitude and so cases are a four-tuple of *name*, *factors*, *dimensions* and *outcome*.

We regard Rigoni's account as improving on Horty's but claim that it cannot deal with questions of balance and trade off [17]. To handle this magnitudes need to be retained and the argumentation needs to become geometric as in [8] and [7]. With one dimension we can think in terms of *left* and *right* (or greater and less than), but with two dimensions we need to think in terms of *north-west* and *south-east* of the various points. The facts of the case and its result define an area where the decision must be followed, and the reason given offers a hypothetical set of facts which creates an area that presumptively favours the winning side. A new case may then fall into an area not yet covered by precedents and, depending on the outcome, will claim some of the space for the winning side. Figure 2 of [7] provides a relevant diagram.

3. How Many Dimensions Must we Consider?

In [8] the discussion was always in terms of two dimensions, but it was left open as to whether higher dimensional spaces might require consideration. In fact, just as any set of relations can be expressed in terms of binary relations and any k-SAT problem can be expressed as 3-SAT, it is possible to represent any domain so as to ensure that only two-dimensional spaces are needed. In [3] the ANGELIC methodology for representing domain knowledge as an Abstract Dialectical Framework (ADF) [13] was presented. Formally an ADF forms a three tuple: a set of nodes, a set of directed links joining pairs of nodes (a *parent* and its *children*), and a set of acceptance conditions to determine the status of the nodes. The nodes represent statements[2], which, in this context relate to issues, intermediate factors and base level factors, and acceptance conditions return a number between 0 and 1 representing the degree to which they favour the plaintiff. The links show which nodes are used to determine the acceptability of other nodes, so that the degree of a parent node is determined by its children. The acceptance condition for a node states how precisely its children relate to that node. In [1] it was shown that such an ADF could be rewritten as a *2-regular ADF*, in which every non-leaf node has at most two children. Since the degree to which a node favours the plaintiff depends only on its children this means that we need never consider more than two dimensions to resolve the acceptability of a node, and, since an ADF produced by the ANGELIC methodology forms a tree, the topmost node can be resolved without the need to consider more than two nodes at any given step.

4. Node Types

Like Rigoni, we recognise that not every aspect of a case requires representation of magnitude. In the original HYPO [6] there were thirteen dimensions. For two of these only one of the two extreme points was of interest; while for eight of them both end points were of interest, but not any intermediate points. One dimension was a set of enumerable points and the remaining two were continuous [9]. These four types represent a Horty style dimension, a pair of Rigoni-style factors, a Rigoni-style dimension and two irreducible dimensions requiring retention of magnitude, respectively. Interpreting these respectively as single factors, pairs of factors, sets of factors and dimensions, a given non-leaf node in our 2-regular ADF (leaf nodes are instantiated from the case facts) may have as children:

1. two factors;

[2]Contrary to the assertions of the reviewers of the original submission, these statements are not limited to two truth values. While originally in [13] they were presented as trivalent, later they were generalised in [14]: "In an ADF, an argument is either accepted (t), rejected (f), or undecided (u). We discuss how the ADF approach can be generalized to allow for more fine-grained distinctions. We consider acceptance degrees taken form an arbitrary domain of values possessing an adequate truth ordering and an information ordering. We show how to accommodate such values using an adequate characteristic operator. We illustrate the approach using degrees in the unit interval". Nor is there, *pace* the reviewers, any difficulty in connecting multi-valued statements with *AND* and *OR*. For example the techniques of fuzzy logic [22] could be used: this was the approach applied to ADFs in [10].

2. one dimension and one factor;
3. two dimensions;
4. one factor (the other child is a dummy node, for example, *true*);
5. one dimension (the other child may be a threshold, allowing the dimension to be coberted to a factor).

(1) is found in factor-based reasoning as formalised in [16] and [20]. In (2) the factor provides a *context* for the consideration of a dimension. In the fiscal domicile example discussed in [18], [15] and [21], citizenship may be a factor: if the person is a UK citizen a longer absence may be required before a change is made. Note that this aspect has no natural interpretation with magnitude: either one is a UK citizen or not. In (3) we have the kind of trade off mentioned above. The two dimensions describe points in a two dimensional space, and a line is drawn separating the area favouring one outcome from the area favouring the other outcome. Examples of (4) should be rare: the child can simply replace the parent. Finally in (5) we have a way of implementing thresholds. Thus the parent will be something like *sufficient absence*, and the purpose of the node is to provide a means of converting a dimension into a factor, much as envisaged by Horty in [16]. A set of such nodes, all with the actual point of the dimension as one child and a threshold as the other, would produce the set of factors envisaged in [21] and [19]. Thus only type (3) nodes will be resistant to the reduction to factors suggested by both [15] and [21], and require the style of reasoning of [8].

5. Relation with Values

Now we can reintroduce a relationship with purposes or values. The idea of values derives from [12] in which values were used to explain preferences between competing factors, and hence to resolve conflicts for which there was no precedent in terms of factors, as explained in detail in [11]. The existence of factors and dimensions in case law domains is justified by their role in enabling the consideration of the particular values the law is designed to promote. In [23] it was recognised that values might play two roles: justifying the presence of a rule, or justifying the inclusion of a particular antecedent in a rule.

In type (1) nodes, where the children are linked by AND, we ensure that both values are promoted, and where they are linked by OR we ensure that at least one of the values is promoted. Thus the role of nodes with two factors as children linked by AND or OR is to ensure that required values are given their due consideration. But there are also cases where the polarity of the two children are different: effectively the connective can be read UNLESS. This expresses a preference for the value associated with the exception. Note that only UNLESS requires a preference: AND or OR consider both values to be of importance.

The second kind of node is where we have a factor providing a context for a dimension. In the fiscal domicile example of [18] the length of absence might be considered differently for different types of citizen. UK citizens might require a longer absence than citizens of other countries who had been working here on a long term, but not permanent, posting. Thus we may envisage a parent *sufficient given citizenship*, with children *UK citizen* and *absence*. What we have here is

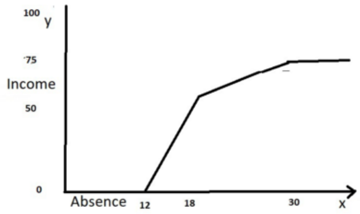

Figure 1. Possible trade off between absence and income percentage. The y-axis represents % income earned in UK, so that increasing values of y favour no change

effectively *two* distinct dimensions with different SPs. Which is used depends on whether the factor is present or not, and the applicable SPs will be specified in the acceptance conditions. The value served here is stability, but the context allows consideration of the value of mobility of labour, since we are allowing non-UK citizens an easier path to restoring their original fiscal domicile. Thus we are able to consider two values, or to consider what promotes a value in a particular context. Similarly nodes of type (5) allow consideration of what is sufficient to promote a value, but where the switching point at which the dimension becomes sufficient is the same for all cases. This permits a threshold for a factor to be determined by precedents, as envisaged in [15]: note that the different thresholds can be applied by using environment variables as antecedents in the acceptability conditions.

This leaves type (3), nodes with two genuine dimensions. Where they are linked by AND or OR, the role of values is the same as for two factors. For example, we can determine whether *both* sufficient absence (to promote stability) and a sufficient degree of engagement (shown by the percentage of foreign earnings, and promoting equity between countries) can be shown, so that the abstract factor *sufficient commitment* can be seen as present in the case. AND and OR, can be resolved using, for example, fuzzy logic style operators. Other type (3) nodes will be those where a balance needs to be struck (see [17]) and so there is a trade off between the dimensions. This is the situation considered in [8].

If we consider that the space can be divided by a single straight line we will have an equation of the form: $y = mx + c$ where m represents the slope of the line, and hence the degree of trade off. Very often, however, m will not be the same for all values of x: the amount of income required to trade off a year's absence, may change as absence increases. A fairly typical situation for absence and income percentage in the fiscal domicile example is shown in Figure 1.

In Figure 1 we have a minimum absence and a minimum percentage of income, with two different rates of trade off in between. To describe this we need a set of four equations covering the various ranges: $0 \leq x \leq 12 : y = 0$, $12 \leq x \leq 18 : y = mx$, $18 \leq x \leq 30 : y = nx$ (where $n < m$) and $x \geq 30 : y = 75$.

The coefficient of x is important because it represents the degree of trade off, the relative weight to be given to the different values at different points. In Figure 1 we have sharp changes of slope, represented by a set of line segments, but often there is a gradual and regular change, better represented by a curve rather than a set of straight line segments, with the gradient varying as a function of x. This function will determine whether the curve becomes increasingly steep or increasingly shallow. In some cases we can imagine the curve changing direction entirely: for a discussion of this point see [7].

In conclusion, we have discussed how we can extend [15] and [21] with dimensions which cannot be reduced to sets of factors.

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