A TYPE-LOGIC APPROACH TO REFINEMENT

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ABSTRACT: Beyond any doubt the pragmatical-based improvements introduced in the rules of inference during the process of refinement of a legal expert system may be efficient but they hardly will be capable to provide a point of reference for a more general correctness measure. During the refinement of KBSLEX the debate of the Theory of Legal Argument has contributed to illuminate the point suggesting that the modeling of legal reasoning and legal decision making should be grounded on a logical approach but without limiting itself to the tools of the classical logic.

Keywords: refinement, expert systems, legal arguments.

1. The debate about the knowledge representation in Artificial Intelligence

In the field of Artificial Intelligence there have been two methodologies for the knowledge representation. One of this is the logic-based methodology and the other is the so called programing procedure. This two approaches have fed the debate of Artificial Intelligence research by criticizing and competing with one other.

The first approach proposes to consider the knowledge as a set of propositions and the true/false judgments as the basic use of reasoning.; from this point of view the aim of the reasoning is to draw correct conclusions. This approach accepts that the classical logic applies well to every issue and it would never tolerate any form of conflict which could lead to an inconsistency.

The second approach, on the contrary, supports that it is necessary to make some practical compromises with logical correctness and consistency in order to reach practical solutions to the actual problems of reasoning, mainly when the presence of uncertainty, incomplete information, non-crisply defined concepts and relations of preference add extra difficults to the task of defining what is a real contradiction (see Prakken 1993).

In order to better understand the differences between both approaches it is worthwhile to briefly draw the theory, first detailed by McCarthy and Hayes in

1969, about the distinctions between the epistemic and heuristic components of knowledge. According to this theory, the epistemic component identifies the what of the knowledge while the heuristic part deals with the how of the knowledge. The first component is typically related to the ontological features of intelligence and could be efficiently represented by the logic-based methodology while the second part is more related to the implementation aspects and makes use of partial representations and algorithms. McCarthy and Hayes propose a knowledge representation mainly directed to the epistemic component which should be independent of the programing.

The actual difficulties that emerge when we intend to use the classical logic in order to represent a reasoning system which deals with incomplete information, exceptions and so on, put into evidence the substantive significance of the heuristic components of the knowledge. On the base of this evidence an important group of researchers has proposed an approach that bases the knowledge representation on the programing methodologies. Marvin Minsky (1967, 1970, 1975), who beyond any doubt is the leader of this approach, supports that it is appropriate for Artificial Intelligence research to use the technics of programing in order to solve the actual problems that emerge in the representation of the knowledge and its rich-context domain. This point of view focuses the attention on the heuristics components of the knowledge and it has succeeded in solving problems of practical implementation in common-sense reasoning, non-deductive inference and reasoning under incomplete information, among others. This developments tend mainly to reach pragmatic goals of knowledge representation and to find some efficient implementation for them; for instance, the production systems have made possible the encoding and applying of human expertise, while the systems based in "frames" are very useful to organize the parts of a knowledge base under a criteria that permits an easy access to the relevant information.

2. The refinement process in Artificial Intelligence

The refinement technics applied to the expert systems are closely related to the heuristic approach; they are directed to modify some components of the knowledge base in order to improve its empirical adequacy and its judgmental expertise; this is the why of the refinement activity. This activity involves the procedures of testing the reliability of the existing rules and eventually the incorporation of plausible modifications of those rules in order to improve the ability of the system to perform in the cases that fall into its domain.

Even though the structure of a given system be in general way correct and it represent an accurate knowledge about its domain of expertise, this shall not be interpreted as an affirmation about the truthfulness and efficiency of *all* the rules of the system; for this reason, in the process of refinement the emphasis is in modifying a number of flaws in a complex structure which is assumed to be basically correct. The procedure generally used in this job consists in the

breaking up of the issues in subissues in order to focus the effort just on the flaws of the structure. In this frame the refinement strategy seems to be always pragmatic since its goal is not directed to modify the system as a logical unit but to improve its empirical adequacy and also should be conservative, preferring less radical changes to more radical refinements, other things being equal.

Most of the refinements procedures could be considered as a generalization or an specialization of the rule that has shown inability to reach a plausible solution. In the first case, the modifications intend to loose the conditions of the rule in order that its conclusion could be easier accepted in a given case; on the other hand, the specialization tends to reinforce the restrictions in order to make harder the acceptability of the rule in a given case; both operations try to meet with the approval of the human experts whose judgments act as the frame of reference.

To summarize, the refinement procedures applied to expert systems should take into consideration the following guidelines:

1. The knowledge base can not be considered as a logical-deductive unit; this mean that the finding of a counterexample to a rule of inference does not invalidate the system as a whole.

2. As the knowledge acquisition is built by the interaction with the human experts, with the semantic context and with a given domain of expertise the expert system is, in some measure, supposed to perform correctly in the cases that fall into such domain.

3. The knowledge base is considered to have performed well in a given case if its conclusion matches the expert's for that case.

4. If the knowledge base does not perform correctly in a given case, the refinement process must be intended; the procedures of generalization and specialization help to correcting the fail rule.

5. The refinement process must be conservative in two ways: on one hand it should be applied only to the proper subset of rules in the knowledge base; on the other hand, it should be a step-by-step process.

2.1. The Theories of Legal Argument and the refinement process in KBSLEX

KBSLEX is a legal expert system initially developed in order to decide when the Venezuelan Criminal Law should be applied to a given case. In order to improve its performance in that field we have used the so called refinement procedures, which are directed to reach in the time t_1 a better solution to the problem of legal expertise that the one got in the time to. (Barragán, J. and Barragán L. 1991)

At the very beginning our refinement approach was basically pragmatic and the refinements were accomplished by deleting or modifying a component on the left hand side of the rule in the case of generalization and by adding or modifying a component on the left hand side of the rule in the case of specialization. Under certain circumstances we have altered the confidence factor associated with the rule's conclusion, making it higher or lower.In this stage, as our task was to improve the empirical adequacy of the knowledge base, we have based our job just on an informal notion of plausibility, which is associated with a loose acceptability of the refinement procedure and mainly with its expected empirical utility. As a result of our activity KBSLEX performed as well as its human counterparts for specific problems and its empirical adequacy was, beyond any doubt, improved.

In spite of the efficiency of the programs we soon understood that our refinement procedures were just mechanic transformations that have lacked a general criteria of validation and even more, they have lacked a theoretical frame of reference; in order to put under critic some alternative solutions to the point we have considered the so called theories of legal argument.

In the field of legal reasoning three different approaches try to explain the conditions under which an argument could be considered as logically acceptable. The first approach represented by the so called standard legal theory works on the supposition that the normative system provides all the necessary information for the inference and it also gives the meta-rules (general principles) for supplanting the essential missing pieces for the legal decision making. (Alchourrón 1986) and (Bulygin 1986). From a different point of view, the non-standard legal theories support that the classical logic seems to be incompetent to address the real problem when we have to model a piece of legal reasoning. For supplanting the classical logic, this approach proposes several non-formal theories which are supposed to be efficient tools to shape the actual legal arguments. (Aarnio, Peczenik 1985). The third approach, agrees with the second position about the inability of the standard legal theory to represent the legal arguments but in order to solve the problem it proposes the development of new methods of formalization (Atienza 1990). The second and third approaches agree in formulating to the standard legal theory the following objections:

1. Its inability to represent the common sense knowledge whose conclusions are based in a large amount of information that is generally considered just as "typically true", "obvious to every body", "a matter of principle" or something like that.

2. Its insufficiency to provide a solution to the problem of non-deductive reasoning or the reasoning under incomplete information.

In spite of this initial agreement both approaches run through divergent ways; while the second approach about legal argumentation uses the former objections in order to show that the inefficiency of the standard theory derives from the presence of many non formal factors in the legal arguments (such as the evaluation of pros and cons, the credibility of the witness, the interpretation of the context and so on) and it proposes the uses of non-formal procedures, the third approach uses the objections to show the inability of the classical-logic formalization and it proposes the use of new formal non-classical-logic based solutions.

From the analysis of the objections and solutions proposed by both approaches, we have concluded that beyond any doubt, the critics directed on the standard legal theory and classical logic-based methodology have greatly contributed to understand the many problems involved in legal reasoning and its representation, but at the same time, we also understood that it would be a serious mistake to conclude that the logic is a superfluous tool that could be efficiently substituted by non-formal procedures.

All these things considered we have finally assumed that only Logics if used in the right way, can provide a systematically interpretable mean of justification, which ensure that the actual legal knowledge represented in the formalism is understandable and the inference methods are verifiable. But facing the complexity of forms of legal reasoning, it seems pointless to think that a single type of formalism or a single logical approach would be capable of representing this wide variety; mainly taking into consideration that the lawyers, using non-orthodox means, are capable of reasoning even when the available information is incomplete and in spite of this, to obtain plausible conclusions. Thus, no logical approach can avoid to deal with all the large number of problems raised by such complex ways of reaching a conclusion in the legal field.

2.2. New postulates to found the refinement procedures in KBSLEX

The concepts and the controversies developed in the field of theory of legal argumentation have also contributed to put into evidence that our original pragmatic procedures of refinement being doubtless efficient in improving the empirical adequacy of KBSLEX, were not precise and general enough to be understood and used by others besides the author. Thus, in order to define a more general and better grounded refinement procedures we have fixed four basic postulates which have been very useful to logically justify the why of the process (Barragán, J. 1993a). These are the four postulates:

1. validity is supposed to be a matter of degree

2. the conclusions are temporary and based on knowledge considered only as "generally true",

3. in the legal field the inference and the decision making are generally made under incomplete information,

4. the knowledge representation should not be independent of the programs.

This four postulates intend to give a more structured and general form to the fact that the knowledge representation is always provisional and we can iteratively improve it. Aarnio's and Atienza's theoretical developments and Atienza's intend of formalization of legal argument have greatly contributed to put into evidence two points: a) That we need a set of general postulates in order to better ground the refinement procedures and b) That this postulates should be conceptually plausible taking into consideration how the legal experts actually argue.

The postulates number 1 and 2 are inspired in the fact that the legal decisions may be improved when a new piece of information is incorporated. This fact obviously contradicts the classical-logic postulate about considering the validity as an "all-or-nothing matter". In order to overcome the limitations of the classical-logic-based approach in expert systems, we have freely took advantage from some concepts of non-formal theories of legal argument and the logic of evolutionary legal systems. On these basis, we can support that in a wide number of questions the limitations of the classical approach derive from the wrong idea that the standard legal theory and its associate the classical logic are the only conceptual tools available for knowledge representation (Barragán, J. 1993b). The postulates Nº 1 and 2 are also coherent with the essential concept of modification of beliefs, which is firmly linked to the dynamism of the normative system.

The postulate Nº 3 takes into account the specific features of the legal domain (softness, ambiguity, vagueness, etc.) and the many ways used by lawyers in order to reach conclusions such as probabilistic inference, inductive inference, common sense reasoning and analogical reasoning among others. The common feature of all these forms of legal reasoning shows them as making always use of incomplete information; in spite of this incompleteness of the information available the legal experts are capable of reaching conclusions and deciding the cases in a reasonable way. The postulate Nº 3 provides an excellent starting point for justifying the use of a variety of logical approaches when shaping the complexity of legal reasoning and decision making.

The postulate Nº 4 is directed to ensure that the logical structures of the system be firmly associated to the programs in order to reach an actual representation of the expert knowledge and a correct performance of the system in a good number of cases. From this postulate, it is possible to understand the refinement not only as the seeking of a better and more elegant logical

structure, but also as a mean of improving the efficiency of the system by the incorporation of plausible modifications to its rules.

We clearly understand that to have the right to be called an "expert system" a computer program must have the ability to perform well in the different cases of a certain domain; this implies that the program should match the human-expert's way to solving the problems in the specific field. For this reason when refining an expert system on one hand we have to give an special attention to the characterization of the rules of inference and to the logical structure of the expert's performance in the cases and on the other hand we have to link such logical structures to the programs. If the logical structure and the programs are independent the task of a well founded and efficient expert system will never be reached.

3. How does the new approach work in the improving of the knowledge representation in KBSLEX

From the postulates Nº 1 and 2 knowledge acquisition and knowledge refinement could be considered as a continuous and unique process directed to improving the knowledge representation. This activity is a complication in any case but in the legal field it becomes an even more complex because of the special features of the normative system, of the legal reasoning and of the legal decision-making (Alchourrón, Bulygin 1971). On the other hand, as legal solving-problem involves many complex logical derivations, any attempt to gather its patterns demands a very serious effort. With respect to the process of refinement, it should be added that many technical problems have to be solved when knowledge-base refinement is designed, since in a general way legal issues tend to resist being broken up into subissues (the procedure generally used in refinement activity) because they often involve extremely complex situations, that are not easy to simplify.

Conceptually we can view the complete process of improving the knowledge representation as consisting of three types of activities which define dynamic cycles of incorporation and deleting of pieces of information in the base:

1. the educing of the set of rules from the expert performance.
2. the educing of the logical strategy used by the expert to reach a right solution.
3. the testing and eventually the revision of the knowledge base.

In drafting the intermediate language used for the representation of legal knowledge in KBSLEX we have first taken into consideration the main issues relating to the coherence and validity of the representation. About the coherence is the problem that during the processes of expansion and contraction,

inconsistencies might be introduced in the base and also is the question that the logical and normative consequences of those activities tend to generate problems of harmonization in the previous system.

In a general way we found that being:

S1: the previous system
I: the incorporated piece
Cn: the logical consequences

$Cn(S1)+Cn(R)$ is not equal to $Cn(S_1+R)$

For this reason, the correctness of every new incorporation should be evaluated both in the field of its empirical adequacy and of its logical coherence. In the field of the empirical adequacy we have used the extensive interviews with legal experts and in order to logically control these inconsistencies and also to define the result base we have used the postulates proposed by Alchourrón and Gärdenfors (1985) for the introduction and the withdrawal of new pieces of information.

For general validation of the revision procedures we have use the method proposed by Gärdenfors and Makinson (1988), based on an ordering on the facts which should be modified. In this approach the ordering relation is based on the "epistemic entrenchment" of the facts that determines the priority according to which the revision should be carried out. During the process of revision, the less entrenchment facts have a higher priority to be updated.

The second issue considered by the proposed intermediate language derives from the special way used by the legal experts to solve a given problem. We found that in order to reach a solution, the experts do not apply the law in an only and unchanging way; they generally do more with the rules than just to follow them. For instance, they can argue about the rules themselves, can propose refinements and even newly formulated rules. (see Gardner 1984).

During the activity of drafting the rules of representation (RR) we found that when a certain law is directed to an specific person, the experts use just the legal rules (LR) and the facts to reach the conclusion; in these cases, the (RR) are the direct representation of (LR). In a second group of cases, the experts use a set of (LR) and the formalisms of the classical logic for the inference, these are the prototypical IF-THEN-based representations. There exist a third group of cases, in which the expert uses a net of (LR) linked by the analogical reasoning; in these cases, (RR) are educed from the (LR) introducing the formalisms of the logic of analogy. Finally we dealt with group of cases that were highly controversial; in these cases the experts introduce an external criteria for the decision making; in such cases the (RR) were shaped using the (LR) and the rules of the logic of rational decision making (Harsanyi 1993).

We have paid an special attention to the logical strategies used by the experts to resolve easy and hard cases. In easy cases, they use the law and the facts as premises, and by the means of the classical logic syllogism they reach the solution. During the interviews with the experts we found that the structure of these relationships can be represented by a scheme that describes them. The scheme organizes the rules and provides a framework for controlling the application of the rules to the case. The (RR) that were educed directly from legislation have the logical form of the "IF-THEN" relations. In this case the (LR) generally address the conditions (or rules) which directly constitute the frame of reasoning. In such cases, as the production rule has the form: "IF A_1 and A_2 and,..., A_n THEN B"; here, the language, the set of axioms and the inference rules of the classical logic are capable to provide an efficient representation.

When the law does not give a direct answer to the case, the experts mainly use the analogical reasoning, which consist in the bringing together of two particular situations considered as analogous, in order to indirectly use the solution given by the law. In these cases the representation is not so simple; the logical specificity of reasoning by analogy consists in inferring that what is true in a particular situation xo should still be so in another situation yo considered similar to xo in some respect.

In this case being:

P and P' are properties of x_0 and y_0 respectively
P and P' are similar in a relevant respect
Q is true for x_0

the production rule has the form:

$P(x_0).....P(y_0)$
IF $Q(x_0)$ is true, $Q(y_0)$ MUST BE true

As we can see, this supposes to extend the language of the classical logic, to add a new scheme of axioms and to re-define the notion of inference; besides this modifications it is also necessary to postulate, from the empirical point of view, a certain dependency between the concerned properties P and P'.

In order to postulate the dependency between P and P' in a given analogy, we had to deal with two different issues: first, which properties should be considered legally relevant in that analogy and secondly, the degree of dependency required between the cases involved in the reasoning in order to consider these case as analogous. It seems to be clear that depending on the type of analogy proposed it is possible to obtain more than one reasonable solution to a given case.

Taking into consideration the agreement about the relevant attributes and the intensity of the dependency between them we found the following situations:

Case Nº 1: agreement about properties
agreement about intensity

Case Nº 2: agreement about properties
disagreement about intensity

Case Nº 3: disagreement about properties
agreement about intensity

Case Nº 4: disagreement about properties
disagreement about intensity

The cases number 1 and 2, (RR) are represented by using the rules of analogical reasoning. The case number 1 (when among the experts there exists agreement about the properties and the intensity) may be considered as an "IF-THEN" case. Case number 2 (agreement about the relevant properties and disagreement on the intensity of the dependency) may be expressed by a fuzzy function. Cases number 3 and 4 (when the experts disagree about the relevancy of the properties) can not be represented by using the rules of analogical reasoning because they put into evidence the presence of adverse rationales.

As we can see, in the cases Nº 1 and 2 the representation could be reached through a two-steps process. In the first step, which is empirically-based and common to both cases, the experts discuss about the proposed analogy and define its basic formulation. In the second step concerning to the case Nº 1 we have used the logic of the standard legal theory for formalizing this structure; while in the second step of the case Nº 2 we have applied a quite different approach, the fuzzy logic, which fitted better to the situation. A set of meta-rules which fixes the appropriate restrictions guides the selection of the right frame for a given case.

The cases Nº 3 and Nº 4 represent hard situations, in which the presence of divergent rationales generates a range of possible right solutions all of them coherent with their initial assumptions. When the hard cases, the experts try to analyze them from different points of view, comparing the diverse rationales and they finally apply an external criteria (for instance the majority criteria) in order to reach a solution which be acceptable for the patterns of the legal rationality. In order to define a well suited logical frame to this procedure we have used the logic of rational decision making which helps to choose one right solution among the range of plausible answers. In such cases we have assigned von Neumann utility functions to each rival alternative and we have preferred, according to the restrictions of an specific set of meta-rules, the solution that maximizes the utility. In the utility function many factual dimensions (political, economic, social and others) are considered.

The third activity directed knowledge representation in KBSLEX consists in testing the performance of the system under different situations. We have first tested it on 30 cases (up to the present on 108) and have made the necessary revisions trying to improve its empirical adequacy. In the refinement of the (RR) the human experts were encouraged to review the logical chain of inference given by the explanation facilities and so the rules could be modified on the basis of the reviewer comments. To formalizing the refinement, we have used structures of the classical logic, the analogical reasoning approach, the logic of hypothetical-cases analysis and the rules of rational decision making under uncertainty.

During the refinement of the system we certainly noted that when the rules are strongly structured in the frame of a rich context they resist to be broken up in subissues. Difficulties of this kind are actual and have been clearly addressed by the so called "isomorphic" approach (Bench-Capon, Coenen 1992; Prakken, Schrickx 1991); but, when we are able to show the logic basis of a representation we are in better conditions to retrace our steps and moreover, everybody will be able to retrace our steps even in a complex context. Probably this is not the easiest way to maintain a legal knowledge base but it is consistent, reasonably efficient and it offers a general frame to guide the refinement procedures under many different conditions.

4. Conclusions

In spite of its efficiency to solve a given problem, the pragmatic-grounded procedures are unable to offer a general validity frame for the refinement of knowledge bases. This lack of generality contributes to isolate the solutions and the most of the times we have been working over and over again in order to reach the same goal through many different and intricate ways. The logical-type approach to refinement problems can give a general point of reference that permit the independent evaluation of the procedures; but taking into consideration that the legal argument is much more than a deductive inference, the classical logic is unable for modeling all the wide variety of reasoning in this field.

Recent developments in the area of the Theory of Legal Argument have been very useful to guide the choice and harmonization of the logical tools better suited for legal knowledge representation; they also have contribute to make the process of refinement not only efficient enough but also more systematic and cumulative.

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