Ontologies and Legal Expert Systems: Implications for Representing the CISG

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Abstract

In recent years those interested in providing firm engineering foundations on which to build knowledge based and expert systems have begun to talk of producing "ontologies" for such systems. In the context of these systems, "ontology" has lost much of its original philosophical meaning. In this context we can best define an ontology for a knowledge based system as an explicit specification of the conceptualisation of its domain. One role of the ontology is to provide the terms in which queries will be posed to, and responses received, from the system. More importantly it definesthe vocabulary which will be used to model the knowledge which the system will contain. As such, the ontology makes available many of the assumptions implicit in the way the knowledge base has been constructed. It has been argued that ontologies have benefits in a number of areas:

- knowledge acquisition;
- knowledge sharing;
- verification and validation;
- knowledge reuse;
- domain theory development;

I shall begin by describing how ontologies can contribute to these topics. This makes a strong case for basing the modelling of any domain on an ontology.

In the remainder of the talk I shall discuss why ontologies are particularly important for the CISG. The CISG itself embodies an implicit conceptualisation of the domain which it concerns. To produce an ontology for the domain which made this conceptualisation explicit would be valuable in itself, and provide a foundation on which otherscan build. It is particularly important for an international instrument such as the CISG because the conceptualisation may have subtle differences from that prevalent in particular contracting states. For example 2(a) uses terms like "family" and "household" which are culturally dependent, and so it is important that their meaning is explicated to avoid variant uses of the terms going unnoticed. As long as assumptions remain implicit there is the danger of mismatches.

The CISG is large, and provides a very suitable vehicle for different research groups to work on. These different groups will bring different assumptions to bear, and will apply different techniques. Integration and exchange of work and ideas could therefore be very fruitful. Integration requires some common framework, and it is notoriously difficult to compare expert systems unless there is some commonality of starting point. I believe that viewing the different efforts in terms of their conceptualisations can provide a basisfor comparison and perhaps yield a framework in which integration might be possible.

Finally what should we do? Two things:

1: Start trying to make explicit the conceptualisation of the CISG

2: Reconstruct the conceptualisations underlying existing approaches to the CISG.

In this way we will extend our understanding both of the CISG and the techniques that have been applied to it.

Representation and Inference of Cases with Fuzziness in CISG

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Abstract

In a legal expert system based on CBR (Case-Based Reasoning), legal experts interpret the statute rule on the basis of precedents. Because of the vagueness and uncertainty in the judgement of the interpretation, the representation and inference of such cases can't be handled by the same means used for crisp cases. In our legal expert system, on the basis of the facts of precedent, the statute rule is interpreted as a form of case rule. The judgement of case rule is represented by the concepts of membership and vagueness. The case rule is stored in a data base by means of fuzzy frames. The inference based on case rule is made by fuzzy YES and fuzzy NO, and the degree of similarity of cases. The system proposed here will be used for the education of law, where the target law of the system is contract, especially as it relates to the United Nations Convention on Contracts for the International Sale of Goods (CISG).

keywords: Case-Based Reasoning, Legal Expert System, Fuzzy, CISG

1. Introduction

Law is applied to represent and handle various ever-changing real events. But the amount of statute of law is limited, complex situations can't be clearly expressed and managed by law text. Therefore, in order to deal with the various real situations, case-based reasoning (CBR) is used in law [Rissland E.L., Ashley K.D. 87]. By applying precedents that are similar to a new case, conclusions for the new case can be reached.

In CBR, in order to apply law to cases, statute rule is interpreted on the basis of facts of precedents. Then judgements as to whether the facts of the case are true to the elements of the interpreted statute rule or not are made. But, there is fuzziness in the judgement. Such fuzziness is caused by the adaptation of a legal concept which is written in limited words applying to a given fact, and the uncertainty of knowledge. Therefore, it is necessary that the representation of cases can describe fuzziness.

Conventional case-based reasoning involves the crisp representation of cases [Kolodner J. 93], and it can't deal with the representation of cases involving fuzziness.

In order to represent the case with fuzziness, and give reasons for the conclusion, fuzzy theory is applied. A judgement with fuzziness is described by concepts of membership and vagueness. Moreover, a method for judging the correspondence of fact and the element of rule by YES and NO from membership function, and an assessment of the similarity of cases with fuzziness are suggested.

Considering the actual decided case of CISG (United Nations Convention on Contracts for the International Sale of Goods) as precedent, an experiment on legal fuzzy inference employing CBR is made.

The CBR for legal inference is introduced in section 2. The representation of cases with fuzziness is described in section 3. The method of inference is presented in section 4. The result of the experiment is illustrated in section 5.

2. CBR for Legal Inference

Legal inference consists of the recognition of facts and interpretation of law. CISG is taken as an example to be discussed here. In CISG, when "the conclusion of contract" is judged, it is necessary at first to judge whether the offer has effect or not. When the effect of the offer has been judged, it is necessary to judge whether the offer is effective or not. When this has been judged, it is essential that the proposal be sufficiently definite, this being defined in statute 14(1) of CISG.

The facts of the case seldom clearly come under the statute rule. For example, the criterion of judgement for "Fixing the price" is not written in statute rule. The statute rule can't be used directly. But legal experts can, by analogy, apply the statute rule to the cases. The new case can thus be inferred.

As for the point of argument to be inferred, the precedent is described by the interpretation of the application of statute rule on the basis of the facts of case. The application of statute rule is that the connections between the facts of the precedent and the statute rule are spread out so that the facts of the precedent satisfy

the legal requirement of statute rule. The connections made between the precedent and statute rule are called a case rule.

According to the degree of similarity of cases, and the judgement for the element of case rule, the case-based reasoning for law can be made.

3. Representation of Case with Fuzziness

Legal knowledge consists of statute rules and precedents. Precedents represent the legal knowledge in CBR.

The Malev v. Pratt Whitey affair is taken to be a precedent.

The situation concerning "The proposal is sufficiently definite" is as follows:

Event: proposal
Description of event:
  The goods are jet engine systems.
  The quantity of engine systems can be calculated by the quantity of planes that will be purchased.
Concerning the price:
  There is no description about the prices of Boeing jet engine systems.
  The price of Boeing jet engine is fixed.
  The jet engine system includes a support package, services and so on.

In accordance with statute 14(1) of CISG, the Hungarian Supreme Court declared that the proposal was not sufficiently definite because the price of jet engine systems was not fixed, and jet engine systems had no market prices.

In this case, it is clear that the goods have been "indicated". It is also clear the "quantity" has been "fixed". It is the "fixing" of the price of entity, consisting of several parts, that needs expert interpretation.
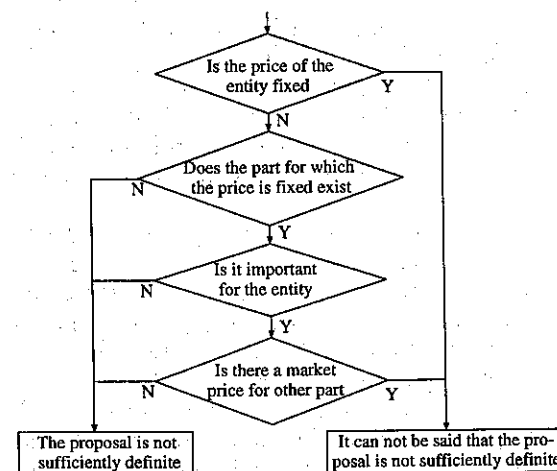
Figure 1: The case rule for the verification of price of entity

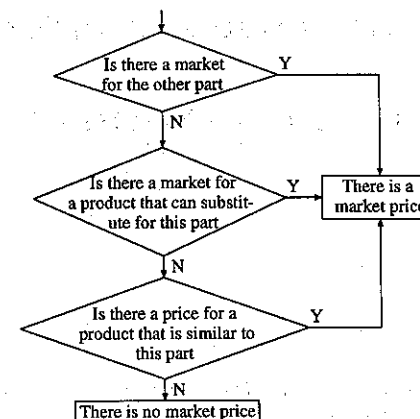The verification of the entity price is interpreted as figure 1.

Figure 2: The case rule for the verification of market price

The process for the verification of the market price is as figure 2.

They are the case rules on the verification of the price of entity in Malev affair.

The hierarchy of case rules is not only a single stage, but it consists of several stages.

There is fuzziness in the judgement of case rule. For example, sometimes it is difficult to clearly answer the question: "Is there a market for other part?" This kind of fuzziness is caused by the fact of a choice of limited words, and the uncertainty of knowledge.

In order to deal with the fuzziness in the judgement of case rule, fuzzy theory is introduced.

Fuzziness can be represented by several methods. We shall use the concepts of membership of fuzzy theory, and vagueness that is presented by the extended fuzzy representation of probabilistic sets to represent fuzziness [Hirota K. et al. 96][Hirota K. 79]. The adaptation that the specific knowledge is described by limited words is represented by the concept of membership. The uncertainty of knowledge is represented by the concept of vagueness.

Table 1: Values of linguistic variables

membership(m)	vagueness(v)
Completely No (CN) 0	Vague (V) 1
Probably No (PN) 0.25	Roughly (R) 0.5
More or Less (ML) 0.5	Clearly (C) 0
Probably Yes (PY) 0.75	
Completely Yes (CY) 1	

There are five values for the input of the membership concept, and three values for the input of the vagueness concept. The membership value is m, and the vagueness value is v. The correspondence between numer-

ical representation and fuzzy linguistic representation is shown in table I.

Figure 3: The Frame on "The proposal is sufficiently definite" in Malev

A triangular membership function can be used to represent the membership function of the fuzziness. The vertices can be defined as:

$$mL = m - mv, \qquad (1)$$

$$mH = m + (1 - m)v, \qquad (2)$$

where mL and mH show the lower limit and upper limit of m, respectively.

When "clearly" is selected from the linguistic variables of vagueness, we get:

$$mL = mH = m. \qquad (3)$$

This means that the membership function becomes a singleton.

The case rule can be represented by a frame, where the name of the frame is the name of legal requirement, the slots are the elements of case rule, the values of slots are the judgements of the elements. The frame is saved in a data base.

The frame that represents the interpretation and judgement of the Malev affair is shown in figure 3.

4. Inference Based on Case Rule

Inference based case rule can be divided into two stages. In the first stage, according to the case rule, the inference is made by the correspondence of the facts of

a new case and elements of case rule in YES or NO. The judgement of YES or NO is made by the fuzzy membership function degree. In the second stage, the inference by the similarity between the new case and the precedent is made.

Conclusions of these two stages are compared the conclusion of the precedent. If they are identical with the conclusion of the precedent, the new case has the same conclusion as the precedent. If they are not identical with it, the new case can't arrive at the same conclusion as the precedent.
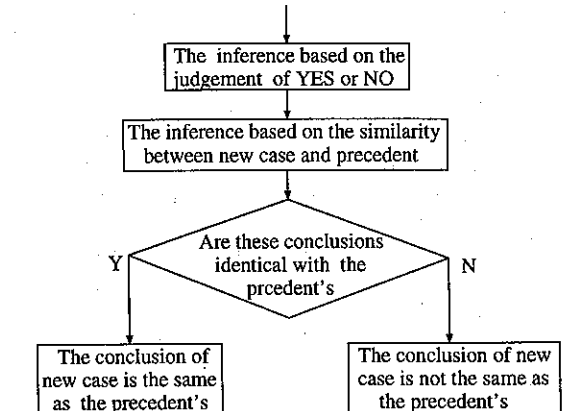
The process of inference is shown in figure 4.

Figure 4: The process of inference based on case rule

Inference Based on a Yes/No Judgement

The judgement on the correspondence of facts of the new case and elements of rule is represented by fuzzy membership function. According to the case rules of figures 1 and 2, a Yes/No judgement is necessary for inference by case rule. The judgement YES or NO is determined by the center of gravity of fuzzy membership function here.

Let C_i be the fuzzy set that describes the judgement of element of case rule for the new case(figure 6).

Membership function of C_i is μ_{C_i}. The center of gravity of C_i can be calculated by

$$CG(C_i) = \frac{\int_{c_1}^{c_2} x \mu_{C_i}(x) dx}{\int_{c_1}^{c_2} \mu_{C_i}(x) dx}. \qquad (4)$$

The center of gravity of C_i belongs to $[0, 1]$. When the value of the center of gravity is near 1, it can be considered that the judgement is YES. When the value of the center of gravity is close to 0, it can be considered that the judgement is NO. The value 0.5 is selected as the threshold. When the value of the center of gravity is greater than 0.5, the judgement is YES. When the value of center of gravity is less than or equal to 0.5, the judgement is NO.

After the correspondences of all the elements of case rules and facts of new cases are judged, the conclusion

as to whether the legal requirement occurs or not is inferred according to the case rule.

Inference Based on Similarity Assessment

A precedent is described by case rules. The similarity between two cases is assessed by the similarity of judgements of the elements of case rule.

Because there is fuzziness in the judgement of rule, the judgement is described as fuzzy set, therefore, the similarity assessment of cases becomes the similarity assessment of fuzzy sets.

The case rule about a point of argument is represented by several frames. Each frame of the precedent and new case can be described as follows:

precedent : $P = \{P_i\}_{i=1}^n$,
new case : $C = \{C_i\}_{i=1}^n$,
P: the frame that represents the precedent,
C: the frame that represents the new case,
P_i: the fuzzy set that describes the judgement of elements of case rule for the precedent(figure 5),
n: the quantity of slots in a frame.

The similarity assessment will be performed as follows:

Membership function of P_i is μ_{P_i}. The center of gravity of P_i can be calculated by

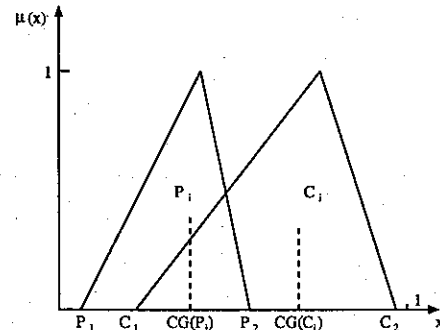$$CG(P_i) = \frac{\int_{p_1}^{p_2} x\mu_{P_i}(x)dx}{\int_{p_1}^{p_2} \mu_{P_i}(x)dx}. \qquad (5)$$

Figure 5: The Similarity of Fuzzy Sets

The degree of similarity is usually shown by a real number in [0, 1], so the degree of similarity $S(P_i, C_i)$ is calculated by

$$S(P_i, C_i) = (1 - |CG(P_i) - CG(C_i)|). \qquad (6)$$

$CG(C_i)$ is calculated by equation(4).
Let $S(P, C)$ be the degree of the similarity of P and C.
It can be calculated by

$$S(P, C) = min(S(P_1, C_1), \ldots, S(P_n, C_n)). \qquad (7)$$

If the degree of similarity is greater than the threshold given in advance, the conclusion of frame C is the same as that of frame P. For example, if there is a conclusion that "The proposal is sufficiently definite" in a precedent, the conclusion of new case is also "The proposal is sufficiently definite." If the degree of similarity is less than the given threshold, the conclusion of frame C can't arrive at the same conclusion as that of P. This does not mean that the new case has the opposite conclusion of the precedent. It is necessary to infer it using other precedent for this new case.

5. The Inference Experiment Based on Case Rule

A reference cases is made for the experiment based on case rule.
The reference case is as follows:
1) On April 1, A in New York dispatched a letter containing an offer to the business branch of a Japanese company B in Hamburg, the content of which is that A sells a set of farming machinery (the price of the tractor itself is $50,000 to B. The tractor should be equipped with a rake, which is product of company C. The farming machinery is delivered by a U.S. cargo ship.)
2) The letter reached B on April 8.

There are several points of argument as to whether the contract is concluded. Whether the proposal from A is effective or not is one of them. On the condition that "The proposal is sufficiently definite," the proposal is effective.

The description of "The proposal is sufficiently definite" is as follows:
Event: proposal
Description of event:
  The goods are farming machinery.
  The quantity of farming machinery is one.
Concerning the price:
  The price of the tractor is fixed.
  The price of a set of farming machinery is not fixed.
  The farming machinery contains a rake.

In the above case the goods are indicated, and the quantity is fixed. The price of the entity is not clearly definite. Therefore, the statute rule can not be directly applied.

In order to judge whether the proposal is sufficiently definite or not, the Malev affair is selected as the precedent which is similar to this case. By quoting the case rule (figure 1, 2)that is applied to verify the price of entity of goods, and by referring to the precedent, the conclusion for the reference cases on the point of argument can be derived.

By means of table I, users can select the fuzzy linguistic variables to answer the elements of rule on term of the fact of the case.

In the proposed fuzzy legal expert system, the user's answers are the inputs. By using the equations (4)-

(7), the Yes/No judgement is made, and the degree of similarity is calculated.

The proposal is sufficiently definite						
	m	v	ml	vl	S	Yes/No
Are the goods indicated	1.0	0.0	1.0	0.0	1.000	Y
Is the quantity fixed or provisions are made for determining the quantity	1.0	0.0	1.0	0.0	1.000	Y
Is the price fixed or provisions are made for determining the price	N				0.750	N

The price is fixed or provisions are made for determining the price						
	m	v	ml	vl	S	Yes/No
Is the price of the entity fixed	0.0	0.0	0.25	0.0	0.750	N
Does the part for which the price is fixed exist	1.0	0.0	1.0	0.0	1.000	Y
Is it important for the entity	1.0	0.0	1.0	0.0	1.000	Y
Is there a market price for other part	N				0.833	N

There is a market price for other part						
	m	v	ml	vl	S	Yes/No
Is there a market for other part	0.25	0.0	0.25	0.0	1.000	N
Is there a market for a product that can substitute for this part	0.25	0.5	0.5	0.5	0.833	N
Is there a price for a product that is similar to this part	0.25	1.0	0.5	0.5	0.917	N

Figure 6: The frame of the reference case on "The proposal is sufficiently definite"

In the reference case the rake of C is probably considered as the exclusive use for the tractor of A, it is not sold on the market. The m1 and v1 in figure 6 represent the value of fuzzy linguistic variables selected by the user. The degree of similarity is displayed in the column S as an output, the Yes/No judgement is displayed in the column Yes/No as another output in figure 6.

The m, v in figure 6 are the same as the m, v in figure 3.

In figure 6, because the conclusions from judgement Yes/No and degree of similarity are the same as the precedent's, the reference case has the same conclusion as the precedent, namely, the proposal is not sufficiently definite.

6. Conclusion

We analyzed an actual decided case in CISG, namely, the Malev case, so that we were able to formulate the case rule. The judgement of elements of case rule was represented by the concepts of membership and vagueness in fuzzy theory. The inference based on case rule is made by the judgement Yes/No and the degree of similarity. The judgement Yes/No was made by a center of gravity of membership function. The degree of similarity was calculated by fuzzy matching. On the basis of these, the inference experiment based on case rule is made. This research enlarged the area of implication of CBR. This method can also be applied in other areas of law containing such fuzziness.

Our case base is currently still small. Therefore, it should be extended. Further, a method for retrieving a precedent which is similar to a new case from the case base should be developed in terms of fuzzy theory.

References

Aamodt A.: 1995, 'Case-based Reasoning: Foundational Issues, Methodological Variations, and System Approaches', *Artificial Intelligence Communications* **Vol. 7 no. 1**, pp. 10–15

Baldwin J.F.: 1994, 'Fuzzy Reasoning by Case for Decision Support Systems', *Int.J.of Uncertainty, Fuzziness and Knowledge-Based Systems* **Vol. 2 no. 1**, pp. 11–14

Hirota K., Kurisu H., Yoshino H.: 1996, 'A Precedent-based Legal Judgement System Using Fuzzy Database', *Int.J.of Uncertainty, Fuzziness and Knowledge-Based Systems* **Vol. 4 no. 6**, pp. 573–580

Hirota K.: 1979 , 'Extended Fuzzy Expression of Probabilistic Sets', *in Advances in Fuzzy Set Theory and Applications, M.M.Gupta et al.(eds.), North-Holland* , pp. 201–214

Kolodner J.: 1993, 'Case based Reasoning', **Morgan Kaufmann Publisher**, pp. 346–352

Nitta K. et al.: 1992, 'HELIC-II: A Legal Reasoning on the Parallel Inference Machine' *Proceedings of the International Conference on the Fifth Generation Computer Systems* , pp. 1115–1124

Rissland E.L., Ashley K.D.: 1987, 'A Case-Based System for Trade Secrets Law', *Proc. of ICAIL'87* , pp. 60–65

Watanabe H., Okuda K.: 1996, 'An Integrated Reasoning Method Using Rules and Cases', *Journal of Japanese Society for Information Processing* **Vol. 31 no. 2**, pp. 244–254 (in Japanese)

Yoshino H. et al: 1993, 'Towards a legal Analogical Reasoning System Knowledge Representation and Reasoning Methods', *Proc. of ICAIL'93* , pp. 110–1165